The

American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

CONTENTS

Contribution to the Biology of Hair ..... Howard Gray and William Campbell Young

Geographical Distribution of the American Drosophilae
of the Subgenus Sophophora ..... Dorcas R. Miller 321

The Chromatophore System of the Crayfish Oligocerus fimbriatus ..... Milton Fingerman 341

Comparative Studies of Developmental Rates, Hibernation, and Food Plants in
North American Cotton Leafworms, Prodenia ..... Shigeo Albert Ae 347

Observations on the Seasonal Occurrence of a Hepatic Trematode Tapeworm
Infecting the Alimentary Tract of Lepus californicus microchirus
Rid. in Albemarle County, Virginia ..... Burton T. Boyton 357

The Function of the Extracardiac Portion of the Mammalian ..... Stuart D. Lander, Jr. 190

Biology of the Oligochaeta Eisenia rosea (Savigny) in Upland
Forest Soil of Southern Michigan ..... William K. Marchie 113

Identification of Adults Stages of Dysmicohen by Leaf Characters ..... Bernard M. Leese, Jr. 137

Certain Aspects of Behavior of the Blacknosed Dace Rhinichthys ..... R. B. Lechleitner 141

Sperm Transfer in the Water-Mite Hygrobates ..... Rodger Mitchell 150

Stoneflies of the Genus Anacroneuria from Mexico,
Central America (Plecoptera) ..... Stanley G. Jewett, Jr. 159

Observations on "Diamond willow" with Particular Reference to Its
Occurrence in Alaska ..... H. J. Lutz 174

Studies of the Byron Bog in Southwestern Ontario. VI.
Seasonal Distribution of Fish Fauna ..... W. W. Judd 188

Notes on Some Snakes from Mississippi ..... J. Willard Gillette 198

A Natural Hybrid Between Black and White Spruce
in Minnesota ..... Elbert L. Little, Jr., and Scott A. Pauley 202

The Larger Plants of Little Sand Lake ..... Robert E. Vincent 210

Notes on Mammals of Southern Illinois ..... James N. Layne 216

Notes and Discussion:

Change in Fish Populations ..... Donald M. Allred 228

A New Variety of Eleocharis Berlandieri ..... B. Bertin 235

Book Reviews 236

Vol. 60 July, 1958 No. 1

ROBERT E. GORDON
Editor

Executive Committee

GEORGE R. BERNARD — GEORGE B. CRAIG
ROBERT P. MCINTOSH — C. S. BACHOFER, C.S.C.

BOARD OF ASSOCIATE EDITORS

B. D. BURKS.....*Entomology*
AUREAL T. CROSS.....*Paleobotany*
ALBERT L. DELISLE.....*Plant Morphology*
CARROLL LANE FENTON.....*Invertebrate Paleontology*
DAVID G. FREY.....*Animal Ecology*
THEODORE L. JAHN.....*General Physiology*
GEORGE NEVILLE JONES.....*Plant Taxonomy*
REMINGTON KELLOGG.....*Mammalogy*
PAUL J. KRAMER.....*Plant Physiology*
JEAN MYRON LINSDALE.....*Ornithology*
GEORGE WILLARD MARTIN.....*Mycology*
ROBERT W. PENNAK.....*Invertebrate Zoology*
HUGH M. RAUP.....*Plant Ecology*
LOREN P. WOODS.....*Ichthyology and Herpetology*

The AMERICAN MIDLAND NATURALIST is a general biological periodical published quarterly by the University of Notre Dame. It welcomes to its pages articles of a descriptive, analytical, and experimental nature. Review articles on topics of current interest in the various fields of Biology are also welcome.

Subscription rate per year $10.00 in the U. S., Mexico, and South American countries; $11.00 elsewhere.

Address All Correspondence to:

AMERICAN MIDLAND NATURALIST
University of Notre Dame
Notre Dame, Indiana

© 1958, University of Notre Dame Press.

Entered as second-class matter at Notre Dame, Indiana. Accepted for mailing at special rate of postage provided for in section 1103; Act of October 3, 1917, authorized on July 3, 1918.

The American Midland Naturalist

Published Quarterly by The University of Notre Dame, Notre Dame, Indiana

VOL. 60 JULY, 1958 No. 1

A Contribution to the Bryology of Haiti

HOWARD CRUM[1] AND WILLIAM CAMPBELL STEERE[2]

In spite of a very long history of botanical exploration in Haiti, surprisingly little is known of the mosses of the country. Only about 10 articles in any way concerned with Haitian mosses have been published, and not one of them is devoted entirely to Haiti, although two are limited to collections from Hispaniola (*i.e.*, Haiti and Santo Domingo together). We have recently studied three large and unusually interesting collections which are reported in detail below, with additional citations to all species previously recorded from Haiti in the scattered literature.

In all, 261 species of mosses are known from Haiti. This number is rather small as compared with a total of 312 from Jamaica; a similar total of 268 species from Puerto Rico, where the flora is almost entirely Caribbean in composition, indicates that a much larger moss flora can be expected in Haiti, with its more rugged topography and greater diversity of habitats, as well as a greater geologic antiquity.

One of the most significant phytogeographic implications of the three collections reported here, as well as E. L. Ekman's collection from Haiti and Santo Domingo reported by Thériot (1944), results from the unexpected discovery in Hispaniola of many genera and species typically continental in distribution. The moss flora of the Antilles has generally been considered much more closely allied to that found in the sandstone and granitic mountains of Venezuela, the Guianas, and eastern Brazil than to the floras of the drier and mostly more calcareous uplands of continental America. Strong continental affiliations are shown by such genera as *Andreaea, Pleuridium, Orthodicranum, Pseudosymblepharis, Leptodontium, Pleurochaete, Grimmia, Orthodontium, Eustichia, Hymenodon, Orthotrichum, Hedwigia, Hookeria, Eriopus, Sciaromium, Heterophyllium* and *Ptilium*. These genera include disjuncts from the ancient Appalachian Plateau of eastern United States, the Cordilleras of Mexico and Central America, and the Andes of South America. They are absent from other parts of the Antilles or, in a few instances, rare and local in Cuba and

[1] National Museum of Canada, Ottawa.

[2] New York Botanical Garden, New York.

Jamaica, but not in Puerto Rico or the smaller West Indian islands. The relatively dry and largely calcareous uplands of Haiti—which have escaped submergence for many geologic ages—provide habitats very similar to the pine forests of upland Mexico and Central America. It is known that portions of the Greater Antilles have been continuously exposed since the Lower Cretaceous, and during part of the time since then were joined to the ancient plateaus of Mexico and Central America (Schuchert, 1935). It seems most likely that disjuncts from temperate eastern North America and also from tropical parts of Middle and South America migrated to Haiti from the west across such a land connection in Tertiary times. There is a particularly strong Appalachian element in the Haitian flora today and this element can scarcely be explained on the basis of migration from the north across the Oligocene "Orange Island" area of Florida because of the low elevation and tropical climates that prevailed during its brief history. A thorough consideration of the origins of the extraneous elements of the local moss flora must await further collection and study. It is worth noting at this time, however, that the continental element is undoubtedly an extremely ancient one which must be considered in connection with the history of Tertiary plant migrations on the mainland. Numerous studies on the Tertiary distribution of the Appalachian-Mexican disjuncts (see Sharp, 1939, 1946, 1951, for example) and Fernald's essay (1931) on the origin of Tertiary relicts characteristic of the youthful Coastal Plain of eastern United States are highly pertinent.

The first certain reference to Haitian mosses appeared in the literature as late as 1890, although it is probable that some of the very early collections such as those made by Olof Swartz, cited merely as Hispaniola, actually came from Haiti. In 1890, Renauld and Cardot described *Philonotis haitensis, Pilotrichella cuspidans, Neckera porodictyon* and *Porotrichum bertrandii* from Haitian types, and in 1894 added *Prionodon haitensis.* Müller (1898) reported 10 species from the country, including a number of new species: *Leucobryum sciurioides, Bryum macrogracilescens, Bartramia picardae, Barbula microglottis* (cited also from Sto. Domingo), *Pottia perconvoluta, Prionodon haitensis* (based on a different type from Renauld and Cardot's species of the same name), *Porotrichum grandidens, Polytrichum obscuroviride* (misspelled *"obscuroviridis";* also cited from Jamaica) and *Dicranum bridelianum* (based on specimens from Puerto Rico and Sto. Domingo, as well). Fourteen years later Britton (1912) recorded the occurrence of *Pilotrichella flexilis* in the area and later (1913) presented a list of 23 species. Williams (1920) described *Calymperes nashii* from a local collection. In 1930 he published on 75 species collected in Haiti by Emory C. Leonard in 1925 and 1926; these included two new species, *Bryum leonardi* and *Pilosium serrulatum.* In 1944 Thériot reported 62 species from E. L. Ekman's collections made in 1917 and 1924-28; his contribution included one new genus (*Cryptoneurum*), eight new species (*Cryptoneurum acumi-*

natum, Campylopus haitensis, Trichostomum (?) *ekmani, Didymodon planifolius, Macromitrium haitense, Ptilium orthothecium, Microthamnium ekmani, Pogonatum ekmani*) and one new variety (*Schlotheimia ciliolata* var. *longifolia*). A number of incidental reports of Haitian species are to be found in papers by Grout (1943, 1945, 1946), Frye and Duckering (1946), Crum (1949, 1952), Crum and Bartram (1958), and Crum and Steere (1956, 1958).

The Société Haitiano-Américaine de Développement Agricole (SHADA), established in 1941, brought to Haiti many outstanding American scientific and technical experts, among them, of course, several botanists. Of these botanists, three made the extensive collections of mosses that form the basis of the present paper. The largest series of mosses, from widely separated and floristically interesting areas, were collected by Dr. Leslie R. Holdridge[3] while Division Manager of the Pine Forest project in the high mountains south of Port-au-Prince, the Morne des Commissaires. His Haitian collections, dating from February 21, 1941 to January 3, 1946, come in large part from various areas of the Morne des Commissaires. He made significant collections on Guimbi Galata (June and July 1942; October 1943; December 1945), Morne la Selle (June and July 1942; October 1943; April 1944; May and November 1945) January 1946), Pic Macayo (February 1941) and Rivière Glace (August 1945) on Morne la Hotte. Between May 6 and July 10, 1941, Professor Harley H. Bartlett of the University of Michigan made extensive and carefully selected collections of mosses in many parts of Haiti, at and near Jérémie, Morne Geffrard, Kenskoff, Citadelle de roi Christophe, Rivière de Plaisance, Grand Rivirère du Nord, Bayeux, Dondon, and Les Trois Sources. As Professor Bartlett was studying problems related to the establishment of rubber plantations, his collections were made at lower altitudes and different areas than those of the other two collectors and so supplement them extremely well. Between October 1, 1943 and July 20, 1944, Mrs. Faith Pennebaker Mackaness made important collections in and near Port-au-Prince and southward into the mountains, while she was in Haiti with her husband. Her main collecting localities are Port-au-Prince, Petionville, Source Turgeau, Morne Hôpital, between Furcy and Kenskoff, and several places in the Morne des Commissaires, as Bassin Bleu, Rivière Glace, Savanne Zombí and Morne la Selle.

The amount of overlap among these three collections is remarkably small, as evidenced by the fact that each collector found many species not collected by the other (or earlier by Ekman). This situation serves to emphasize the richness of the Haitian moss flora and gives some indication of the important discoveries that can be expected when a professional bryologist visits Haiti.

In the following catalogue all the species known from Haiti are

[3] Now at the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

listed, with detailed citations only for specimens which we have examined. These include the collections made by Holdridge, Bartlett and Mackaness, all preserved in the herbarium of the University of Michigan, as well as numerous other specimens which have come to our attention incidentally over a period of several years. In all 261 species and a few trivial taxa are listed below; these include nine new species and two new combinations.

SPHAGNACEAE

Sphagnum erythrocalyx Hampe *ex* C.M. (Thériot, 1944, as *S. guadalupense* Schimp.). —West Indies; Coastal Plain from New Jersey to Louisiana; British Honduras; South America.

Sphagnum meridense (Hampe) C.M. (Thériot, 1944). Pic Macayo, Morne la Hotte, 5500 — 7500 ft., *Holdridge* 603, Feb. 21, 1941. — Florida; Mexico to South America; West Indies.

Sphagnum subsecundum Nees. Morne la Selle, 1850 m, *Holdridge* 3128, Nov. 27, 1945. — Europe and Asia; Labrador to the Gulf of Mexico and Washington to California; Mexico, Guatemala, Isle of Pines (Cuba) and Haiti.

FISSIDENTACEAE

Fissidens angustifolius Sull. (Grout, 1943). For notes on problems of nomenclature, see Crum & Bartram, 1958). — Cuba, Jamaica, Haiti, Puerto Rico and Trinidad; British Honduras and Guatemala.

Fissidens asplenioides Hedw. Jardin Bois, Morne des Commissaires, *Holdridge* 3174, 3175, 3177a, 3180, 3185a, 3192, Jan. 3, 1946. Roadside between Furcy and Kenskoff, *Mackaness* 155, July 18 - 20, 1944. — Tropical and austral latitudes around the world.

Fissidens bryoides Hedw. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3121a, Dec. 16, 1945. Rotting log in hardwood area, pinelands above SHADA sawmill no. 1, Morne des Commissaires, *Mackaness* 138, March 19, 1944. — A puzzling species, or complex of species, said by Grout (1943) to occur in eastern United States and Canada, Vancouver Island, Florida and Puerto Rico, as well as in Europe. At least some of the tropical material so-named by Grout can be referred to *F. repandus* Wils. The entire range in this hemisphere, particularly in tropical America, should be confirmed.

Fissidens cristatus Wils. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3083, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3103, 3134, Dec. 16, 1945. Morne Vincent, 2200 m, *Holdridge* 3172, Jan. 2, 1946. The setae are 8 - 10 mm long, thus corresponding to Limpricht's measurements of European material; those given by Grout in the *North American Flora* (1943) are probably in error. — Europe, Asia, eastern North America, Aleutian Islands; Mexico, Honduras, Haiti.

Fissidens densiretis Sull. On tree fern, hardwood area in pine-

lands, Morne des Commissaires, *Mackaness* 87, Apr. 28, 1944. —Cuba, Haiti, Puerto Rico and Guadeloupe.

Fissidens dissitifolius Sull. In drainage ditch, Bassin Bleu, *Mackaness* 115a, June 1944. —Cuba, Jamaica, Haiti, Puerto Rico, Mexico, Guatemala.

Fissidens elegans Brid. Osman, Morne la Selle, 1650 m, *Holdridge* 3008, 3026, 3029, 3035a, May 15, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3102, 3106, 3121, 3137, 3138, 3140, Dec. 16, 1945. On humus, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 89a, March 18, 1944, 47 Apr. 28, 1944, 216, March 19, 1944. —West Indies; Mexico to South America. Williams (1930) reported *F. acicularis* C.M., a Brazilian species unknown to us, on the basis of two sterile collections (*Leonard* 7586, 8085); Grout (1943) did not mention these specimens but said that *Ule* 236 from Brazil, named *F. acicularis* by Brotherus (and very likely the basis of Williams' concept), belongs here.

Fissidens garberi Lesq. & James. (Williams, 1930). Citadelle, *Bartlett* 17739, May 22, 1941. Steep hillside, mountains above Kenskoff, *Mackaness* 181, Jan. 19, 1944. Cemetery, Morne Hôpital, above Port-au-Prince, *Mackaness* 234, Dec. 30, 1943. Dry woods, Canapé Verte, above Port-au-Prince, *Mackaness* 230, 281, May 1944. — Florida to Louisiana; West Indies and Bermuda; Mexico to northern South America; Cocos Island.

Fissidens kegelianus C.M. (Williams, 1930; Grout, 1943). Vicinity of large springs at source of Rivière Tissier, Grand'Anse valley, near Mare Franc, 6 km SW. of Jérémie, *Bartlett* 17569, May 6, 1941. Bayeux, *Bartlett* 17757, 17760, 17771, June 19-24, 1941. On soil in woods, Canapé Verte, above Port-au-Prince, *Mackaness* 283, May 1944. — Florida; West Indies, Mexico to northern South America.

Fissidens leptopus Card. On mortar, cemetery near Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 108, Jan. 1944. Roadside between Kenskoff and Furcy, *Mackaness* 165, July 18 - 20, 1944. Bayeux, mouth of Rivière de Port Margot, *Bartlett* 17759, June 19 - 24, 1941. The characters which Grout (1943) used to distinguish *F. leptopus* Card. from *F. ravenelii* Sull. are untenable. As in *F. ravenelii*, the dorsal lamina in *F. leptopus* does not clearly or by any means consistently and abruptly at the junction of stem and leaf but tapers to the stem or sometimes ends gradually to somewhat abruptly somewhat above the stem. Furthermore, the marginal leaf cells may bear one papilla or two in either species, although those of *F. ravenelii* are perhaps more frequently bipapillate. The two species are closely related, but the border on the vaginant laminae of upper stem and perichaetial leaves in *F. ravenelii* is very distinctive as compared with that of *F. leptopus*. It is broader and composed of broader cells and *intramarginal for some distance above the base*, and, moreover, the margin of the vaginant lamina is nearly always irregularly toothed by the projection of cell angles. The leaves of *F. leptopus* are at most papillose-crenulate at the margins, and the border is strictly

marginal. That Grout was unaware of the intramarginal nature of the border in *F. ravenelii* is clearly demonstrated by his key and by his description of *F. densiretis* var. *latifolius,* based on three specimens, *Steere* 5635 and 6686 from Puerto Rico and *Marie* 114 from Guadeloupe. The Puerto Rican specimens can be referred to *F. ravenelii;* the third specimen, which by default may constitute the type, has not been seen. (It is perhaps *à propos* to mention here that Grout's citation of *Sullivant & Lesquereux* 192 as *F. ravenelii* should be corrected to read 102.) The Mexican type of *F. leptopus* (originally spelled "*leptopodus*") has been compared with abundant authentic material of *F. ravenelii.* — Haiti, Puerto Rico, Trinidad; Mexico, Guatemala, British Honduras.

Fissidens mollis Mitt. (Williams, 1930). On soil, Canapé Verte, above Port-au-Prince, *Mackaness* 282, May 1944. — West Indies; Mexico to South America.

Fissidens muriculatus Spruce *ex* Mitt. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3188a, Jan. 3, 1946. — West Indies; Guatemala and perhaps Mexico (Grout, 1943); northern South America.

Fissidens petrophilus Sull. (Thériot, 1944.) This species was omitted from Grout's recent revision of the Fissidentaceae (1943). According to the authors, *F. imbricatus* Britt. & Bartr. of Jamaica and Cuba (*Bro. León* 4081; *Webster* 808, 907) differs from *F. petrophilus* in having curled and recurved, proliferous stems, longer setae and inclined or arcuate capsules. In addition, in *F. imbricatus* the costa ends 2 - 4 cells below the apex of the leaf and is not particularly flexuose, and the apical lamina is very short and reduced; in *F. petrophilus,* on the other hand, the costa is more or less flexuose above, ending 4 - 6 cells below the apex, and the apical lamina is not reduced. Thériot (1939-41) characterized *F. petrophilus* as related to *F. similiretis* but easily recognized by the following features: stems long and slender, up to about 2.5 cm, leaves plane, 3 mm long and 0.3 mm broad, the vaginant laminae reaching about ¾ the length of the leaf and the areolation of very incrassate, pellucid cells. The two statements of relationship cited above are rather difficult to reconcile with Grout's treatment of *F. imbricatus* in the section Aloma and *F. similiretis* in the section Amblyothallia; oddly enough, under *F. imbricatus,* Grout said, "Possibly this species should be placed in Amblyothallia," an opinion also endorsed by Mr. Bartram (*in lit.*). — Cuba, Jamaica and Haiti.

Fissidens polypodioides Hedw. (Britton, 1913). Guimbi Galata, Morne des Commissaires, ca. 1550 m, *Holdridge* 3049, 3076, May 20, 1945. Source Turgeau reservoir area, Morne Hôpital, above Port-au-Prince, *Mackaness* 107, Dec. 16, 1943. Roadside between Furcy and Kenskoff, *Mackaness* 204, July 18 - 20, 1944. On tree, Plaisance to Marmelade, about 2500 ft., *Nash* 666, Aug. 23, 1903. — Southeastern U. S.; Mexico to South America; West Indies; Bermuda.

Fissidens taxifolius Hedw. Hardwood hummock in pinelands,

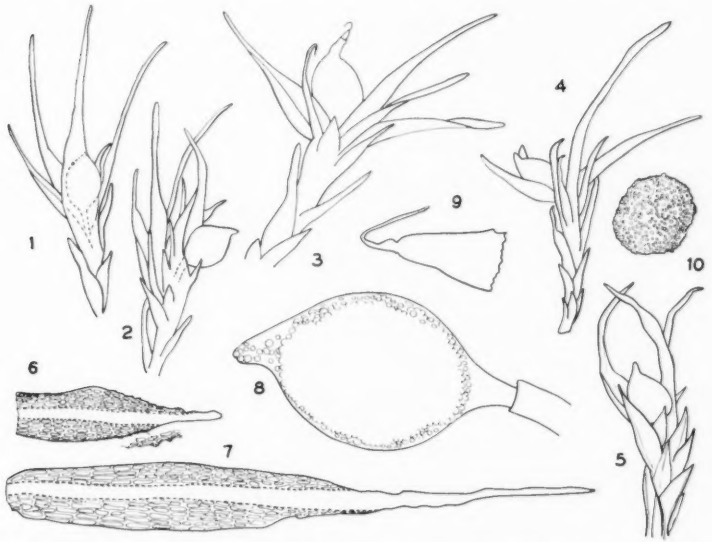
Morne des Commissaires, *Mackaness* 48, 113, 139, 261, March 19, 1944. — Europe, eastern North America, Arizona, Guatemala, Jamaica and Haiti.

Fissidens vardei Thér. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3134a, 3145b, Dec. 16, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3010a, 3022, May 16, 1945. — Cuba, Jamaica, Haiti and Puerto Rico.

Fissidens yucatanensis Steere. (See Crum & Bartram, 1958). Limestone ledge above forestry headquarters, Morne des Commissaires, *Mackaness* 98, Apr. 28, 1944. On damp soil, La Coup trail, near Port du Paix, *Leonard* 12172 (in herb. N. Y. as *F. augustifolius*). — Jamaica, Haiti, Puerto Rico, Yucatan (Mexico).

DITRICHACEAE

Pleuridium (Sclerastomum) **holdridgei** n. sp. Plantae pusillae, flavovirentes, 2-3 mm altae. Caules simplex vel prope basem parce ramosi. Folia erecta, prope basem caulis imbricata, parva, remota, ovato-lanceolata, acuta vel apiculata, distincte serrata, cellulis breviter oblongis, costa percurrente vel breviter excurrente, prope apicem caulis lanceolata, acuminata, 1.2-1.5 mm longa, subintegra vel serrulata, costa excurrente, cellulis lineari-rhomboideis, 4-5 : 1, parietibus plus



Figs. 1-10.—*Pleuridium holdridgei.* 1-5.—Habit sketches, 1, ×45; 2, ×22; 3, ×17; 4, ×16; 5, ×18. 6.—Lower leaf, ×67. 7.—Perichaetial leaf, ×50. 8.—Sporophyte, ×50. 9.—Calyptra, ×50. 10.—Spore, ×467.

minus incrassatis. Setae perbreves. Capsulae immersae, ovoideae, 272-330 μ latitudine, 363-370 μ altitudine et in apiculo obtuso, 86-132μ alto terminatae. Sporae sphaericae, dense et minute papillosae, 19 μ. Calyptrae conico-mitratae, laeves, 300 μ altae.

Small, yellow-green, gregarious or scattered plants, 2-3 mm high. Stems simple or sparsely branched near base. Leaves erect, scarcely altered when dry, lower imbricate, small and distant, ovate-lanceolate, acute to apiculate, distinctly serrate, with short-oblong cells and costa percurrent to short-excurrent, upper and perichaetial lanceolate-acuminate 1.2-1.5 mm long, serrulate to subentire, with costa excurrent and filling most of subula, cells linear-rhomboidal, 4-5 : 1, moderately incrassate. Setae very short. Capsules immersed, ovoid, 272-330 μ wide, 363-370 μ long (not including the stout, blunt apiculus which is 86-132 μ high), stomatose at base. Spores spherical, densely and finely papillose, 19 μ in diameter. Calyptra conic-mitrate, irregular but not lobed at base, smooth, 300 μ high. (Figs. 1-10.)

On roadbank (with *Fossombronia*), Jardin Bois, Morne des Commissaires, 1600 m alt., *Leslie R. Holdridge* 3179, Jan 3, 1946 (type in herb. University of Michigan).

The position of the antheridia could not be determined with certainty, but they appear to be naked in the axils of lower or median leaves. The lower leaves are quite different from the upper in size, shape and areolation and in the development of the costa which becomes progressively longer and more excurrent toward the stem apex. The teeth on the margins of the lower leaves are curiously doubled; they are formed by the projection of the ends of two adjacent cells. Distinctive features of the species are the very small lower leaves grading toward the stem apex from a minimum of about 0.2 mm in length and the small capsules which, including the apiculus, are only about 0.5 mm or less long. *Pleuridium holdridgei* seems most closely related to *P. mexicanum* Card., which was very briefly described from a collection of only four fertile plants. The type has not been available for study. Mrs. Britton, in the *North American Flora* (1913), provided what seems to be an unsatisfactory description; according to her, the leaves are entire and only the lower ones can be considered appressed. Another Mexican specimen (*Arsène* 7962, determined by Cardot) is very similar in habit and structure to the type of *P. holdridgei* and has the same kind of teeth on the lower leaves, but the stems are about 7-8 mm high, the upper leaves 2 mm or more long and the capsules conspicuously longer than broad, about 1 mm in length.

Ditrichum rufescens (Hampe) Hampe. Osman, Morne la Selle, 1650 m, *Holdridge* 3020, May 15, 1945. — Mexico to Brazil; West Indies.

Ceratodon purpureus (Hedw.) Brid. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3176, Jan. 3, 1946. — Nearly cosmopolitan but infrequent in tropical America and largely replaced in warmer latitudes throughout the world by *C. stenocarpus* BSG.

DICRANACEAE

Dicranella brachyblepharis (C.M.) Mont. (Thériot, 1944). South of Kenskoff, *Bartlett* 17683, May 18, 1941. Jardin Bois, Morne des Commissaires, *ca.* 1600 m, *Holdridge* 3186, 3197a, Jan. 3, 1946. — Mexico, Guatemala, Jamaica and Haiti.

Dicranella herminieri Besch. (Williams, 1930). — Coastal Plain of southeastern United States; West Indies; Mexico, Honduras, Costa Rica and Panama.

Dicranella nicholsii Williams. Morne la Selle, 1700 m, *Holdridge* 3005, 3007, May 15, 1945. — Apparently known otherwise only from the type collection from Jamaica.

Dicranella varia (Hedw.) Schimp. Steep hillside, mountains above Kenskoff, *Mackaness* 175, Jan. 19, 1944. — Europe, Africa and Asia; North America south to Guatemala; Cuba, Haiti and Jamaica.

Campylopus angustiretis (Aust.) Lesq. & James. (Williams, 1930). — Florida; Haiti and Puerto Rico.

Campylopus cubensis Sull. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 2092, Aug. 4-7, 1945. — Cuba, Jamaica, Haiti, and Puerto Rico.

Campylopus cygneus (Hedw.) Brid. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 598, Feb. 21, 1941. — Cuba, Jamaica, Haiti, Puerto Rico, Sto. Domingo.

Campylopus fragilis (Dicks.) BSG. Osman, Morne la Selle, 1650 m, *Holdridge* 3028, May 15, 1945. Hardwood area in pinelands, Morne des Commissaires, *Mackaness* 37, 68, 69, March 19, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 213, July 1944. — Florida; Cuba, Jamaica, Haiti and Puerto Rico; Mexico and Guatemala; Europe, Asia, Africa.

Campylopus haitensis Thér. (1944). — Endemic.

Campylopus saxatilis Williams (Thériot, 1944). — Cuba, Jamaica, Haiti and Puerto Rico and Dominica.

Campylopus tortuosus (Hampe) Par. (Williams, 1913). On bank, La Brande to "Mt. Balance," *G. V. Nash* & *N. Taylor* 1719. At 1000 m alt., Morne Bellance, Dépt. Artibonite, *W. Buch* 829. Both these collections are represented by duplicates at the National Museum of Canada; *Nash* 1719 was originally named by Williams *C. penicillatus* (Hornsch.) Jaeg., a name which does not appear in his revision (1913), although it has been used rather frequently for West Indian specimens which can be referred to *C. tortuosus*. — Cuba, Haiti and Puerto Rico.

Holomitrium calycinum (Hedw.) Mitt. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 594, Feb. 21, 1941. — Cuba, Jamaica and Haiti; British Honduras.

Holomitrium marginatum Mitt. (Thériot, 1944). — Cuba and Haiti.

Orthodicranum flagellare (Hedw.) Loeske. Morne Vincent, Hold*ridge* 3165, 3171, Jan. 2, 1946. Top of Morne la Selle, 2575 m, *Hold-*

ridge 1890, Apr. 24, 1944. — Europe, Asia, southern Canada, eastern United States, Mexico, Guatemala, Haiti.

Leucoloma cruegerianum (C.M.) Jaeg. Roadside between Furcy and Kenskoff, *Mackaness* 214. — Mexico to northern South America; West Indies.

Leucoloma serrulatum Brid. (Müller, 1898, as *Dicranum brideliánum* C. M.). On bark, Rivière Glace—Jérémie road, *Mackaness* 17, Nov. 1943. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 59, March 19, 1944. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3104, 3109, 3127, Dec. 16, 1945. — West Indies; Mexico to northern South America.

LEUCOBRYACEAE

Leucobryum albicans (Schwaegr.) Mitt. (Thériot, 1944). Osman, Morne la Selle, 1650 m, *Holdridge* 3030, May 15, 1945. — West Indies; Costa Rica, South America.

Leucobryum albidum (Brid.) Lindb. Base of pine tree, forestry headquarters, Morne des Commissaires, *Mackaness* 56, March 17, 1944. — Europe, eastern United States, Mexico and Central America, West Indies, Bahamas.

Leucobryum antillarum Schimp. (Müller, 1898, as *L. sciurioides* C. M.; Williams, 1930). Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3030a, May 15, 1945. Base of tree, hardwood area at base of Morne la Selle, *Mackaness* 54, 274, March 18, 1944. — Florida; West Indies; Central America; northern South America.

Leucobryum polakowskyi (C. M.) Card. (Thériot, 1944). Jardin Bois, Morne des Commissaires, 1550 m, *Holdridge* 1217a, May 15, 1942. Base of pine tree, Morne des Commissaires, *Mackaness* 55, March 17, 1944. — West Indies; Trinidad; Mexico and Central America.

Octoblepharum albidum Hedw. (Britton, 1913; Williams, 1930; Thériot, 1944). Base of shade tree, south of Savanne Zombí, Morne des Commissaires, *Mackaness* 57, March 18, 1944. Dry woods and ravines above Source Turgeau, Morne Hôpital, *Mackaness* 228, Oct. 1943. — Pantropical, ranging northward to Florida.

Octoblepharum pulvinatum (D. & M.) Mitt. On bark, Camp Perrin—Rivière Glace road, *Mackaness* 21, Nov. 1943. — West Indies; Guatemala and British Honduras to Costa Rica; northern South America.

CALYMPERACEAE

Syrrhopodon berterianus (Brid.) C. M. Hardwood pocket in pinelands, Savanne Zombí, Morne des Commissaires, *Mackaness* 94, Apr. 28, 1944. On rotten log, Massif du Nord, Port-de-Paix, Haut-Piton, *ca.* 1150 m, *Ekman* 4863, Sept. 20, 1925, *c. fr.* — West Indies; Costa Rica; Trinidad; northern South America.

Syrrhopodon incompletus Schwaegr. Corticolous in dry woods,

Morne Hôpital, above Port-au-Prince, *Mackaness* 100, Jan. 1944. Hardwood pocket in pinelands, Savanne Zombí, Morne des Commissaires, *Mackaness* 57a, 94a, Apr. 28, 1944. Dry woods, Canapé Verte above Port-au-Prince, *Mackaness* 283, May 1944. — Florida; West Indies; Mexico to Paraguay.

Syrrhopdon lycopodioides (Sw.) C. M. (Britton, 1913). — West Indies; Guatemala and Costa Rica; northern and western South America to Bolivia.

Syrrhopodon prolifer Schwaegr. South side of Morne Geffrard, *Bartlett* 17673a, May 13, 1941. Old log in pinelands, Morne des Commissaires, *Mackaness* 60, March 17, 1944; 24, March 18, 1944. Guimbi Galata, Mornes des Commissaires, 1700 - 1800 m, *Holdridge* 3119a, 3120a, 3137a, Dec. 16, 1945. Bois Contre near Morne la Selle, *Orcutt* 3474, March 22, 1929. — Florida; West Indies; Mexico to South America.

Calymperes donnellii Aust. Vicinity of large springs at source of Rivière Tissier, Grand'Anse valley, near Mare Franc, six km SW. of Jérémie, *Bartlett* 17572a, 17571, May 6, 1941. Plaisance-Pilate, *Bartlett* 17751a, June 15, 1941. — Florida; West Indies; Mexico to northern South America; Cocos Island.

Calymperes lonchophyllum Schwaegr. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3084a, Aug. 4 - 7, 1945. — Central America; West Indies; South America.

Calymperes nashii Williams (1920). — Florida; Haiti and Mono Island (Puerto Rico).

Calymperes richardii C. M. Bayeux, *Bartlett* 17764, 17768, 17774, 17785, June 19 - 24, 1941. Corticolous in dry woods, Morne Hôpital above Port-au Prince, *Mackaness* 100a, Jan. 1944. Roadside between Furcy and Kenskoff, *Mackaness* 183, July 18 - 20, 1944. On tree, Bayeux, near Port Margot, sea level, *Nash* 160, Aug. 5, 1903. On mango tree, Morne Chavary, vicinity of St. Louis du Nord, *Leonard* 14435, March 30 - Apr. 7, 1929. — Florida; West Indies; Mexico to northern South America.

POTTIACEAE

Anoectangium euchloron (Schwaegr.) Mitt. Jérémie westward to Trou Cochon, chalk exposures facing sea, 50 - 300 ft., *Bartlett* 17608, May 9, 1941. Citadelle, *Bartlett* 17736, May 22, 1941. Pinelands, Morne des Commissaires, *Mackaness* 8, 64, 273, Apr. 28, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 201, 206, July 18-20, 1944. — Africa, East Indies, Philippine Islands, and Hawaii; mountains of North Carolina; tropical America.

Anoectangium incrassatum Broth. *ex* Borg. (Thériot, 1944). — Cuba, Jamaica, Haiti and Puerto Rico.

Hymenostomum breutelii (C. M.) Broth. Dry woods near Source Turgeau, above Port-au-Prince, *Mackaness* 106, Dec. 16, 1943. Terrestrial, ravine above Source Turgeau, *Mackaness*, May 1944. Soil around tombs, cemetery, Morne Hôpital, above Port-au-Prince,

Mackaness 235, December 30, 1943. — West Indies; Costa Rica; Brazil.

Hymenostomum castaneum n. sp. Plantae 2-3 cm altae, dense caespitosae, castaneae. Caulis innovando ramosus. Folia sicca valde crispata, madida laxe erecta, apicibus saepe incurvata, 2 mm longa, oblongo-lanceolata, acuta et apiculata, concava, apicibus cucullata, marginibus infime subintegra vel sinuata, supra integra autem papillosa, apicibus incurvata vel involuta; costa flava, breviter excurrens, basi 48-56 μ lata; cellulae superae parvae, 5-6 μ, subquadratae, dense papillosae, basilares brunneo-flavae, laeves, incrassatae, prope costam lineares, ad margines breve oblongae, invalidos limbos supra basem formantes. Dioicum? Seta 5-7 mm longa, flava, aetate brunnescens. Capsula subcylindrica, subbrunnea, gymnostomo, orificio columella apice dilatata clausa. Operculum ignotum. Sporae flavae, laeves, 11-14 μ.

Plants in deep, compact, chestnut-brown tufts 2-3 cm high. Stems branching by innovations. Leaves strongly crisped when dry, loosely erect, often with incurved points, from an erect base when moist, 2 mm long, oblong-lanceolate, acute and rather stoutly apiculate, concave, cucullate at apex, with margins subentire to sinuate below, entire except for marginal papillae above, incurved to involute at tip; costa yellow, excurrent as a short apiculus, 48-56 μ wide at base; upper cells small, 5-6 μ, rounded-quadrate, densely papillose and very obscure, basal cells yellow-brown, smooth, with very incrassate walls, linear within, short-oblong and pale at margins forming an indistinct border which extends slightly above the shoulders. Apparently dioicous (antheridia not seen). Setae 5-7 mm long, yellow, becoming brownish. Urn of capsule ovoid-cylindric, pale-brown, covered on dehiscence by a pale, fugacious membrane; operculum not seen. Spores smooth, yellow, 11-14 μ.

On the ground, Pic Macayo, Morne la Hotte, 5500-7500 ft., *Leslie R. Holdridge* 595, Feb. 21, 1941, type (in herb. University of Michigan).

It is a pleasure to describe an attractive and well-marked species in such a troublesome genus as *Hymenostomum*. The tall plants crowded in deep tufts of a rich-brown color are not likely to be mistaken for anything else, and the very incrassate walls of the basal leaf cells, often as thick as the lumina, are a unique feature of the species.

Weissia controversa Hedw. var. *australis* (Aust.) Schornh. A specimen which Williams (1930) reported as *Weissia viridula* var. *amblyodon* (Brid.) BSG, though sterile, appears to belong to this widespread tropical American variant of *W. controversa*. It is not at all clear what *W. viridula* var. *amblyodon* is. Paris' *Index Bryologicus* gives its distribution as Europe, Asia and California and lists *W. brandegeei* Aust. as a synonym. The variety is not included in Grout's *Moss Flora of North America*, but *W. brandegeei* is to be found there in the synonymy of *W. viridula* (= *W. controversa*). — West Indies; southeastern U. S. north to North Carolina.

Gymnostomum recurvirostrum Hedw. Guimbi Galata, Morne des Commissaires, 1770 m, *Holdridge* 1770, June 21, 1942. Roadside between Furcy and Kenskoff, *Mackaness* 182, 200, July 18 - 20, 1944. Morne des Commissaires, *Mackaness* 7, Apr. 28, 1944. Citadelle, *Bartlett* 17732, May 22, 1941. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3082, May 20, 1945. Thériot (1944) reported *Barbula ehrenbergii* (Lor.) Fl. from Haiti, based on *Ekman* 5501, but the specimen under that number in the U. S. National Herbarium is *Gymnostomum recurvirostrum*. — Nearly cosmopolitan.

Eucladium verticillatum (Brid.) Bruch & Schimp. On limestone, forestry headquarters, pinelands, Morne des Commissaires, *Mackaness* 271, March 1944. — Europe, Africa, Asia, North America and Mexico; Bermuda.

Tuerckheimia linearis (Sw.) Britt. (Britton, 1913). — Cuba, Jamaica, Haiti and Puerto Rico.

Trichostomum angustifolium n. sp. Plantae parvae, ca. 5 mm altae, rigidae, dense caespitosae, flavido-brunneae. Caulis simplex. Folia sicca valde crispata et spiraliter contorta, madida erecto-patentia et flexuosa, plus minus fragilia, 5-6 mm longa, linearia e basi breviter oblonga, acuta et apiculata, concava, marginibus erecta, undulata, plus minus irregularia, basi integra; costa basi 55-80 μ lata, breviter excurrens; cellulae basilares pallidae, laeves, laxe oblongae, superae parvae, 6-8 μ, quadratae et sexangulares, dense papillosae. Dioicum? Caetera ignota.

Plants small, about 5 mm high, rigid, in dense, low yellowish to brownish mats. Stems simple. Leaves strongly crisped and spirally contorted when dry, erect-spreading and flexuose when moist, often broken, 5-6 mm long, linear from a short, oblong, slightly wider base, acute and apiculate, concave with margins erect, undulate, irregularly notched along the limb, entire below; costa 55-80 μ wide at base, excurrent as a short, yellow apiculus; basal cells pale, smooth, laxly rectangular, not forming a border at the shoulders, upper cells small, 6-8 μ, quadrate and hexagonal, obscure, densely papillose. Apparently dioicous (antheridia not seen). Sporophyte lacking.

On soil, southward from Kenskoff (alt. 4300 ft., 24 km south of Port-au-Prince) to the crest of the mountain ridge (alt. 5600 ft.) on limestone or red residual soil overlying limestone, *H. H. Bartlett* 17694, May 18, 1941 (type in herb. University of Michigan).

This new species, with its erect, undulate and irregularly notched margins, belongs in the relationship of *T. cylindricum* (Bruch) C. M. It bears considerable resemblance to *Tortella mollissima* in the shape of its leaves and its lax basal cells, and it is suspected that the two have been lumped together, elsewhere in the tropics of America, by ourselves and others, for want of a better name for plants lacking a narrow marginal border of pale, lax cells at and above the shoulders. A thorough study of the difficult *Tortella mollissima* problem will

doubtless result in further subtractions from the current concept, but, in the meanwhile, it is useful to have a name for this species locally and perhaps more widely in the West Indies.

Trichostomum ? ekmanii Thér. (1944). — Cuba and Haiti.

Trichostomum involutum Sull. Chardonette, *Bartlett* 17647, May 11, 1941. South of Kenskoff, *Bartlett* 17684, 17696, May 18, 1941. Crest south of Kenskoff, *Bartlett* 17705, 17719, May 18, 1941. Mountains above Kenskoff, *Mackaness* 154, Jan. 19, 1944. — Bermuda; West Indies.

Trichostomum jamaicense (Mitt.) Jaeg. (Williams, 1930; Thériot, 1944). Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3081, May 20, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3011, May 15, 1945. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3097, Aug. 4 - 7, 1945. Roadside between Furcy and Kenskoff, *Mackaness* 164, 178, 180, 263, July 18-20, 1944. On banks, Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 112, Dec. 16, 1943; 226, Dec. 30, 1943. Boulder, mountain slopes, Kenskoff, *Mackaness* 152, Jan. 19, 1944. Cayaba to Moron, on road between Dame Marie and Jérémie, *Bartlett* 17585, May 8, 1941. Jérémie westward to Trou Cochon, facing the sea, 50 - 300 ft., *Bartlett* 17599, 17605, 17607, 17681, May 9, 1941. Chardonette, 2000 ft., *Bartlett* 17613, 17621, 17646, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17651a, 17656, May 13, 1941. South side of Morne Geffrard, *Bartlett* 17677, May 13, 1941. Wooded summit south of Kenskoff, *Bartlett* 17729, May 18, 1941. Citadelle, *Bartlett* 17733, May 22, 1941. North of Morne Geffrard, *Bartlett* 17816, July 10, 1941. — Oklahoma, Texas, Arizona to Guatemala; West Indies.

Trichostomum mutabile Bruch. Limestone in cemetery, Morne Hôpital, above Port-au-Prince, *Mackaness* 131, Dec. 30, 1943. Roadside between Furcy and Kenskoff, *Mackaness* 131, July 18 - 20, 1944 (det. Bartram). Steep hillside, mountains above Kenskoff, *Mackaness* 130, Jan. 19, 1944. Because of the more bluntly pointed leaves these plants have been referred here rather than to *T. cylindricum* (Bruch) C.M., in accordance with a suggestion made by Mr. Bartram. *T. mutabile* (*T. brachydontium* Bruch) is also known from Madeira, Canary Islands, Europe, Asia, Africa, New Zealand, Texas, Mexico, Guatemala, Ecuador and Jamaica.

Trichostomum sublamprothecium Par. Hardwood area above SHADA sawmill no. 1, Morne des Commissaires, *Mackaness* 132, 133, 262, 276, March 19, 1944. Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3081, May 20, 1945. — Jamaica, Haiti and Puerto Rico.

Pseudosymblepharis schimperiana (Par.) Crum (Crum, 1952). — Mexico, Guatemala, Costa Rica, Cuba, Jamaica and Haiti.

Tortella humilis (Hedw.) Jenn. [Williams, 1930, as *T. caespitosa* (Schwaegr.) Limpr.] Chardonette, *Bartlett* 17649, May 11, 1941. North of Morne Geffrard, *Bartlett* 17811, July 10, 1941. — Eastern

North America; Arizona to Guatemala; South America; Galapagos Islands; Jamaica, Haiti and Puerto Rico; Europe and North Africa.

Pleurochaete luteola (Besch.) Thér. (Thériot, 1944). Top of Morne la Selle, 2575 m, *Holdridge* 1892, Apr. 24, 1944. Morne Vincent, *Holdridge* 3169, Jan. 2, 1946. On base of pine, above SHADA sawmill no. 1, Morne des Commissaires, *Mackaness* 91, March 19, 1944, 33, March 17, 1944, 197, March 26, 1944. — Mexico, Guatemala, Ecuador, Peru and Haiti.

Leptodontium ulocalyx (C. M.) Mitt. Morne Vincent, *Holdridge* 3167, Jan. 2, 1946. An interesting addition to the Caribbean flora of a common species of Mexico, Guatemala, Costa Rica and Venezuela. Var. *cirrifolium* (Mitt.) Bartram. Thériot's report of *L. subcirrifolium* (C. M.) Par. very likely belongs to this rather unimportant variant, which is distinguished only by having longer, more rugose leaf tips. The type of *L. subcirrifolium* seems nearly identical with such specimens of the variety *cirrifolium* as have been available for study. — Mexico, Guatemala, Panama, Colombia, Ecuador and Haiti.

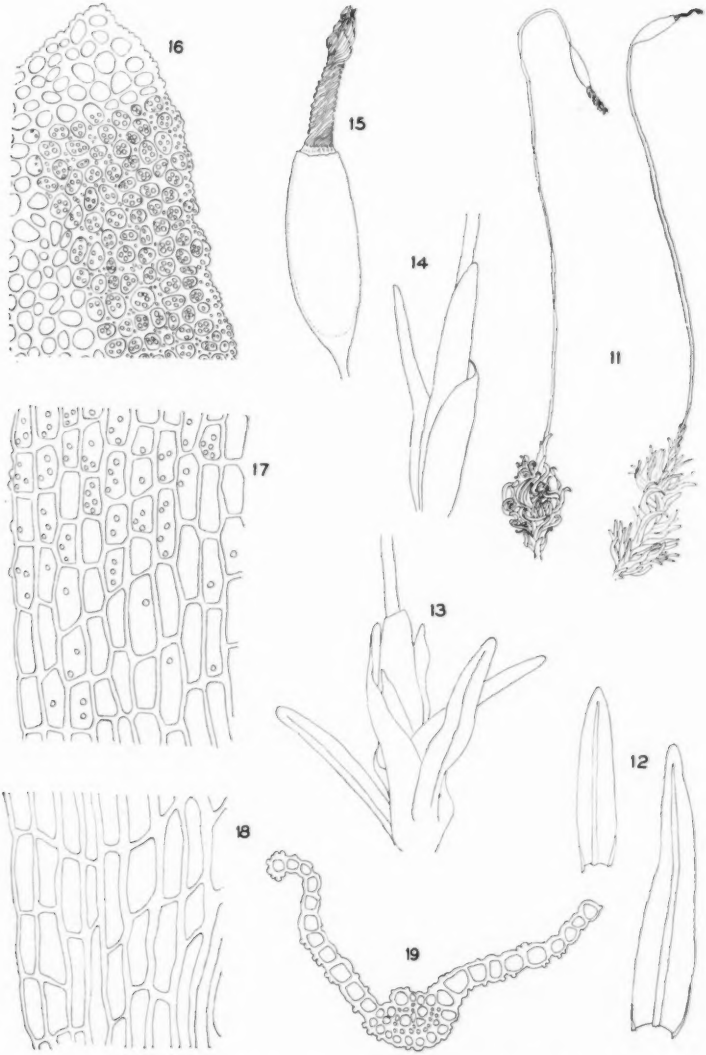
Hyophila tortula (Schwaegr.) Hampe. (*Pottia perconvoluta* C. M. 1898; Williams, 1930). Jérémie westward to Trou Cochon, chalk exposures facing sea, 50-300 ft., *Bartlett* 17600, May 9, 1941. Chardonette, *Bartlett* 17631, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17668, 17670, 17671, May 13, 1941. Citadelle, *Bartlett* 17738, May 22, 1941. Limbe—Plaisance, *Bartlett* 17738, May 22, 1941. Bayeux, *Bartlett* 17770, June 19 - 24, 1941. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3097a, Aug. 4 - 7, 1945. Roadside between Furcy and Kenskoff, *Mackaness* 173, 205, July 18 - 20, 1944. Cemetery, Morne Hôpital, above Port-au-Prince, *Mackaness* 227, Dec. 30, 1943. — Eastern North America; West Indies; Arizona to northern South America.

Didymodon planifolius P.-V. & Thér. (Thériot, 1944). — Endemic.

Didymodon tophaceus (Brid.) Jur. Chardonette, 2000 ft., *Bartlett* 17630a, May 11, 1941, *c. fr.* — Haiti; Europe, Africa, Asia, North America southward to Guatemala; northern South America.

Barbula cruegeri Sond. *ex* C. M. (Williams, 1930). Old mill race near Rivière Valdrogue, east of Jérémie, ca. 50 ft., *Bartlett* 17597, May 8, 1941. Chardonette, *Bartlett* 17628, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17666, May 13, 1941. South to Kenskoff, *Bartlett* 17688a, 17691, May 18, 1941. On limestone, Source Turgeau, Port-au-Prince, *Mackaness* 225, Dec. 16, 1943. — New Jersey to Texas; West Indies; Mexico to northern South America.

Barbula fidelis n. sp. Plantae parvae, flavo-virentes. Caulis 5-6 mm altus, simplex vel innovando ramosus. Folia sicca contorta, madida laxe erecta, 1-1.5 mm longa, ligulato-lanceolata, subacuta vel obtusa vel rotunda; costa flava, sub apicem folii evanida; cellulae superae ca. 6 μ, dense papillosae, basilares pallidae, laeves, oblongae, ca. 4 : 1. Dioica. Folia perichaetiales erecto-convoluta, ligulata



Figs. 11-19.—*Barbula fidelis*. 11.—Habit sketches, dry (left), moist (right), ×7. 12.—Stem leaves, ×25. 13-14.—Perichaetia, ×25. 15.—Capsule, ×25. 16.—Cells at leaf apex, ×467. 17.—Cells near leaf shoulders, ×467. 18.—Cells at leaf base, ×467. 19.—Cross-section of upper portion of leaf, ×467.

e basi oblonga, 2 mm longa. Seta flava, tenuis et flexuosa, 11-13 mm longa. Capsula flavido-brunnea, 1.5 mm longa, cylindrica; operculum alte conicum, obtusum, 1 mm longum; dentes peristomii obscurate rosei, 1 mm longi, valde torquati. Sporae sphaericae, laeves, 8 μ.

Small, yellow-green plants. Stems 5-6 mm high, simple or branched by repeated innovations. Leaves contorted when dry, loosely erect when moist, 1-1.5 mm long, ligulate-lanceolate, bluntly acute or obtuse or rounded; costa yellow, ending well below apex; margins entire, plane; upper cells small and obscure, *ca.* 6 μ in diameter, densely papillose, basal cells pale and smooth, rectangular, about 4:1. Apparently dioicous; perichaetial leaves erect and sheathing, ligulate from a broader base, 2 mm long. Setae yellow, slender and flexuose, 11-13 mm long. Capsules yellow-brown, 1.5 mm long, cylindric; operculum high-conic, blunt, 1 mm long; peristome dull-pink, twisted 1½ times, 1 mm long. Spores smooth, spherical, 8 μ. (Figs. 11-19.)

Path through pineland, forestry headquarters, Morne des Commissaires, *Faith P. Mackaness* 72, March 19, 1944 (type in herb. Bartram).

The specimen at the University of Michigan could not be located, and the above description was taken from a duplicate kindly furnished by Mr. Bartram. The species belongs in the general relationship of *B. convoluta* Hedw. Its erect, sheathing perichaetial leaves, yellow seta, plane leaf margins and particularly its costa ending well below the apex and the blunt or rounded leaf points are, in combination, distinctive features. The specific epithet has been chosen as a Latin approximation of the collector's Christian name.

Barbula leptodontoides n. sp. Planta parvae, rigidae, obscurate brunneo-virides vel flavo-virentes, caespitosae. Caulis brunneo-ruber, erectus, tenuis et flexuosus, simplex. Folia 1-1.5 mm longa, sicca erecta, apicibus incurvata, madida erecto-patentia vel late patentia e basi breviter oblonga et convoluta, supra sensim attenuata, apiculata, marginibus mediis foliorum plus minus late revoluta; costa breviter excurrens; cellulae superae parvae, obscurae, dense papillosae, basilares pallidae, laeves, oblongae. Dioica. Folia perichaetiales 2 mm longa, acuminibus erectis, lineari-lanceolatis. Caetera ignota.

Plants small, rigid, in dull, brownish- or yellowish-green tufts. Stems brownish-red, erect, slender and flexuose, simple. Leaves 1.0-1.5 mm long, erect with incurved points when dry, erect-spreading or widely spreading from a short, oblong, concave, sheathing base when moist, gradually tapered from the shoulders to a slender, blunt point; margins rather widely revolute at the shoulder, plane above; costa prominent and rounded at back, short-excurrent as a small, pellucid mucro, in section showing 2 stereid bands; upper cells small, obscure and densely papillose, lower cells pale, smooth and oblong. Dioicous; perichaetial leaves 2 mm long, with erect, linear-lanceolate points. Sporophyte unknown. (Figs. 20-38.)

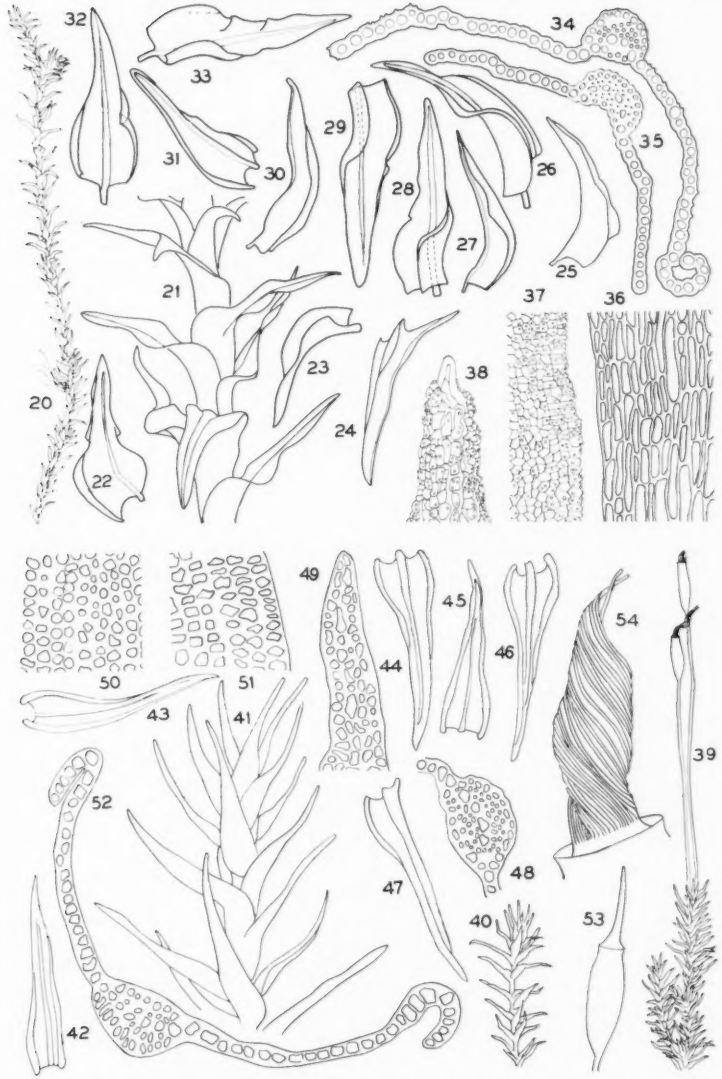
Beaumont to Morne Geffrard, 2000-2600 ft. alt., Arrondissement de Jérémie (north of divide on road from Les Roseaux to Les Cayes), southern peninsula, *H. H. Bartlett* 17651, 17655 (type), May 13, 1947 (University of Michigan).

The gametophytes are quite characteristic in appearance because of the leaf points which are erect and incurved above a clasping base when dry, but usually widely spreading when moist. The rather widely revolute margins at the shoulders and the spreading tips of the leaves are reminiscent of some of the small species of *Leptodontium,* but the small, obscure, densely papillose cells and the minute, hyaline apiculus formed by the slightly excurrent costa leaves little question as to a true relationship to the *Barbula cruegeri* complex. *Barbula leptodontoides* is similar in many ways to *B. purpuripes* C. M. of Jamaica, especially in the gradually and slenderly tapered leaf points and their erect-incurved position on the stem when dry, as well as the minute apiculus and the rather well differentiated perichaetial leaves; in *B. purpuripes,* however, the leaves are plane at the margins rather than revolute as in *B. leptodontoides.*

Barbula lurida Hornsch. Roadside between Furcy and Kenskoff, *Mackaness* 136, July 18 - 20, 1944. Originally described from a Brazilian collection, *B. lurida* is also known from Trinidad, Cuba and Mexico and probably occurs throughout the lowlands of tropical America where it has been much confused with *B. subulifolia* Sull. Indeed the two species are close allies, and the differences between them may be subject to considerable variation; *B. lurida* can be distinguished, at least in the extreme, by broad leaf apices and clearly reflexed margins.

Barbula microglottis C. M. Müller (1898) cited the type collection, presumably Haitian, as "St. Domingo, prope Cap Haytien ad habitationem Picard." — Endemic.

Barbula subteretiuscula Card. Limestone crest of mountain ridge southward from Kenskoff (24 km south of Port-au-Prince), 5600-6000 ft., *Bartlett* 17704, 17713, May 18, 1941. Southward from Kenskoff (alt. 4300 ft., 24 km south of Port-au-Prince) to the crest of the mountain ridge (alt. 5600 ft.), on limestone or red residual soil overlying limestone, *Bartlett* 17688, 17695, May 18, 1941. On bank in pinelands, Morne des Commissaires, *Mackaness* 264, March 1944. This species is reported here with some reservation. Quite a large number of species have been described in the difficult complex of *B. bescherellei* Jaeg. & Sauerb. and *B. acuta* (Brid.) Brid., most of them based on characters no more tangible or consistent than relative size, deepness and looseness of tuft, degree of marginal revolution and relative length of the fleshy subula formed by the excurrent costa. The problem is particularly acute in Mexico because of Cardot's many additions to the register of names in this group. These local collections are a fairly good match for *B. subteretiuscula,* but it is questionable whether it might not be more realistic, as well as much simpler, to allow *B. bescherellei* greater latitude in variation to include such



Figs. 20-38.—*Barbula leptodontoides*. 20.—Habit, ×4. 21-33.—Leaves, ×25. 34.—Cross-section below leaf shoulder, ×220. 35.—Cross-section of upper portion of leaf, ×220. 36.—Basal leaf cells, ×217. 37.—Upper leaf cells, ×217. 38.—Apex of leaf, ×217. Figs. 39-54.—*Barbula subteretiuscula*. 39.—Habit of fertile plant, ×3. 40.—Habit of sterile plant, ×4. 41.—Portion of sterile plant, ×20. 42-47.—Leaves, ×25. 48.—Cross-section of upper portion of leaf, ×220. 49.—Apex of leaf, ×220. 50.—Lower leaf cells, ×220. 51.—Upper leaf cells, ×220. 52.—Cross-section of basal portion of leaf, ×220. 53.—Capsule, ×8. 54.—Peristome, ×50.

slightly smaller and somewhat more rigid forms with rather shorter fleshy leaf tips. The accompanying figures (39-54), drawn from Haitian material, may eventually help in clearing up the current confusion. — Haiti and Mexico.

Barbula subulifolia Sull. Road from Les Cayes to Les Roseaux, north of Morne Geffrard, *Bartlett* 17817, July 10, 1941. — West Indies; Mexico, Guatemala and Costa Rica; Ecuador.

Desmatodon sprengelii (Schwaegr.) Williams. Cemetery near Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 109, Dec. 15, 1943, 111, Dec. 16, 1943. On damp rock, vicinity of Jean Rabel, *Leonard* 12787, Feb. 4, 1929. — Florida; Mexico, Guatemala and British Honduras; West Indies.

Luisierella barbula (Schwaegr.) Steere. Cemetery, Morne Hôpital, *Mackaness* 224, 230, Jan. 1943. — Florida and Texas; Cuba, Jamaica, Haiti, Puerto Rico, New Providence and Abaca; Bermuda; British Honduras.

Splachnobryum mariei Besch. (Thériot, 1944). — Otherwise known from Guadeloupe.

Splachnobryum obtusum (Brid.) C. M. (Williams, 1930). Jérémie westward to Trou Cochon, southern peninsula, 5 - 300 ft., *Bartlett* 17603, May 9, 1941. Bassin Bleu, in drainage ditch, *Mackaness* 115, June 1944. Sides of concrete drainage canal, Bizerton, near Port-au-Prince, *Mackaness* 11, Jan. 23, 1944. — West Indies; Costa Rica.

Gymnostomiella orcuttii Bartr. (Crum, 1949). Baie des Flamonds, [collector unknown] 9096, Aug. 15, 1928 (*ex herb.* Pagán). The only local collection of this minute and attractive species was included among a series of mosses collected in Haiti by the late Dr. Francisco Pagán, but the number of the collection does not seem to belong to Pagán's series of collecting numbers. — Florida; Jamaica, Haiti and Puerto Rico; eastern Mexico.

Tortula agraria (Hedw.) Sw. (Williams, 1930, as *Barbula*). Gayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17586, 17593, May 8, 1941. Jérémie westward to Trou Cochon, on chalk exposures facing sea, 50 - 300 ft., *Bartlett* 17604, May 9, 1941. Chardonette, *Bartlett* 17619, May 11, 1941. Limbe—Plaisance, *Bartlett* 17746, May 24, 1941. Bayeux, *Bartlett* 17779, June 19 - 24, 1941. Cemetery near Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 22, 110, Dec. 15, 1943. Wall of charcoal kitchen, Source Turgeau, above Port-au-Prince, *Mackaness* 229, March 1944. On cemetery wall, Petionville, *Mackaness* 113, Jan. 1944. Saltrou, *Mackaness* 223, March 17, 1944. — Florida, Louisiana and Texas; West Indies; Mexico to Guatemala; northern South America.

Tortula fragilis Tayl. On rock, SHADA forestry headquarters, Morne des Commissaires, *Mackaness* 61a, Apr. 28, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 144, July 18 - 20, 1944. — Virginia and West Virginia; southwestern U. S. to northern South America; Haiti.

Tortula mniifolia (Sull.) Mitt. Les Trois Sources, *Bartlett* 17786,

July 8, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 184, July 18 - 20, 1944. — West Indies; Trinidad; Mexico, Guatemala, Costa Rica; western South America to Bolivia and northern Peru.

FUNARIACEAE

Funaria calvescens Schwaegr. (Williams, 1930). Osman, Morne la Selle, 1650 m, *Holdridge* 3037, 3039, May 15, 1945. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3181, Jan 3, 1946. Morne la Selle, 1700 m, *Holdridge* 3002, May 15, 1945. Marie Claire, Morne des Commissaires, *Holdridge* 1206, May 14, 1942. Morne Carotte, Morne la Selle, 1800 m, *Holdridge* 1308, July 3, 1942. In pinelands, Morne des Commissaires, *Mackaness* 62, 63, March 17, 1944. Chardonette, *Bartlett* 17624, May 11, 1941. South of Kenskoff, *Bartlett* 17697, May 18, 1941. Crest south of Kenskoff, *Bartlett* 17706, May 18, 1941. — Throughout the world in the tropics and subtropics.

Entosthodon bonplandii (Hook.) Mitt. [Thériot, 1944, as *Funaria paucifolius* (C. M.) Broth.] — West Indies; Trinidad; Mexico, Guatemala and Costa Rica; South America.

BRYACEAE

Orthodontium pellucens (Hook.) BSG. [Thériot, 1944, as *Stableria osculatianum* (DeNot.) Broth.; Meijer, 1951.]. — Western Europe, California, Mexico, Guatemala, Costa Rica, South America, Cuba, Jamaica and Haiti.

Brachymenium systylium (C. M.) Jaeg. On tree trunk, trail to Pic de Brouet, vicinity of Furcy, about 1950 m, *Leonard* 4595a. Pinelands, Morne des Commissaires, *Mackaness* 270, March 1940. — Florida; southwestern U. S. to South America; West Indies.

Brachymenium wrightii (Sull.) Broth. (Thériot, 1944.) — Cuba, Haiti and St. Vincent.

Pohlia flexuosa Hook. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 1219, May 15, 1942, 3177, 3183, 3185, 3187, 3197, Jan. 3, 1946. Andrews (1950) has given the distribution as "widely distributed in the tropics or near tropics of the New and the Old World (Africa temporarily excluded)."

Pohlia integridens (C. M.) Broth. District Ranger Station, Morne des Commissaires, 1580 m, *Holdridge* 864, Oct. 17, 1941 (det. Bartram). — Mexico, Guatemala, Costa Rica, Colombia.

Bryum argenteum Hedw. Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17580, May 8, 1941. Crest south of Kenskoff, *Bartlett* 17703, May 8, 1941. Citadelle, *Bartlett* 17737, May 22, 1941 (var. *lanatum*). On soil, forestry headquarters, Morne des Commissaires, *Mackaness* 76, 192, 243, March 17, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 170, 176, July 18 - 20, 1944. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3181, Jan. 3, 1946 (var. *lanatum*). Morne Carotte, Morne la Selle, 1800 m, *Holdridge* 1308a, July 3, 1942. Morne la Selle, 1700 m, *Holdridge* 3003, May 15, 1945. — Cosmopolitan.

Bryum capillare Hedw. Morne la Selle, 1700 m, *Holdridge* 3001, May 15, 1945. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3182, 3193, Jan. 3, 1946. On logs, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 50, March 19, 1944. Citadelle de roi Christophe, *Bartlett* 17738a, May 22, 1941. Chardonette, *Bartlett* 17627, May 11, 1941 (det. Andrews). The last specimen bears abundant propagula, such as those described in detail by Correns (1899). — Nearly cosmopolitan.

Bryum cavifolium Schimp. *ex* Besch. (Thèriot, 1944). — Guadeloupe, Cuba and Haiti.

Bryum coronatum Schwaegr. (Williams, 1930). Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17582, 17590, 17592, 17594, May 8, 1941. Les Trois Sources, *Bartlett* 17791, July 8, 1941. Morne Geffrard, *Bartlett* 17810, July 10, 1941. — Pantropical, north to Florida.

Bryum cruegeri Hampe *ex* C. M. Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17576, May 8, 1941. Chardonette, *Bartlett* 17623, 17633, 17642, 17648, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17661, May 13, 1941. Grand Rivière du Nord—Dondon, *Bartlett*, 17755, June 15, 1941. Trois Sources, *Bartlett* 17787, 17793, July 8, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 174, July 18 - 20, 1944. Camp no. 4, Marmelade, *Nash* & *Taylor* 1291, Aug. 1 - 2, 1905. — Georgia and Florida; West Indies; Mexico to South America; Trinidad.

Bryum leonardii Williams (1930). — Endemic.

Bryum leptocladon Sull. South of Kenskoff, 4300 ft., 24 km south of Port-au-Prince, to crest of ridge, *Bartlett* 17688, 17697a, May 18, 1941. — Cuba, Jamaica, Haiti, Puerto Rico, Guadeloupe and Martinique.

Bryum limbatum C. M. Beaumont to Morne Geffrard, *Bartlett* 17664, May 13, 1941. North of Morne Geffrard, *Bartlett* 17815, July 10, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 208, 209, July 18 - 20, 1944. — Cuba, Haiti, Puerto Rico, Grenada and Guadeloupe; Mexico, Guatemala and Costa Rica.

Bryum macrogracilescens C. M. (1898). On tree limb in montane mossy forest, 6200 ft. alt., summit of Morne Guimbi, above Morne des Commissaires, *G. R. Proctor* 10836, Sept. 16, 1955. This specimen was determined from the description and sent to Dr. Harumi Ochi, who considers it one of the forms of an Asiatic and Pacific species, *Bryum ramosum* (Hook.) Mitt., near the variety *decaisnei* (Dozy & Molk.) Ochi. (He has also referred a specimen from Vancouver Island and two from Colombia to *B. ramosum.*) — Endemic.

Bryum truncorum Brid. (Williams, 1930, as *B. andicola* Hook.). On humus, hardwood area in pinelands, Morne la Selle, *Mackaness* 38, March 18, 1944. Hardwood area in pinelands, Morne des Commissaires, *Mackaness* 193, 241, 266, March, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 137, July 18 - 20, 1944. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 595a, Feb. 21,

1941. The last specimen, from the highest peak in southern Haiti, has a peculiar greasy texture not common among mosses and bears a general resemblance to certain species of *Brachymenium*. Dr. Andrews has said that the plants, though by no means normal, probably represent a form of the variable *B. truncorum*. — Rather general in the Southern Hemisphere; Tennessee; southwestern United States to South America; Cuba, Jamaica and Haiti.

Rhodobryum domingense (Brid.) Besch. [Müller, 1898, as *B. swartzianum* C. M.; Williams, 1930, as *R. schwartzianum* (C. M.) Par.; Thériot, 1944]. Near Mare Sal, Morne des Commissaires, 1600 m, *Holdridge* 1375, July 28, 1942. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3044, 3063, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3099, Dec. 16, 1945. On humus, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 89, March 18, 1944. South of Kenskoff, *Bartlett* 17685, May 18, 1941. — Widespread in the West Indies and possibly throughout the American tropics under a variety of synonyms.

MNIACEAE

Mnium longirostrum Brid. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3045, 3071, May 20, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3033, May 15, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3135a, 3141, 3141a, 3150, Dec. 16, 1945. Base of tree fern, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 45, 239, March 18, 1944. — Nearly cosmopolitan but more abundant in warmer regions.

RHIZOGONIACEAE

Hymenodon aeruginosus (H. f. & W.) C. M. Osman, Morne la Selle, 1650 ft., *Holdridge* 3038, May 15, 1945. On tree fern, hardwood area, in pinelands, Morne des Commissaires, *Mackaness* 43, Apr. 28, 1944. — Cuba, Jamaica and Haiti; Brazil.

Rhizogonium spiniforme (Hedw.) Bruch. (Britton, 1913; Thériot, 1944). Osman, Morne la Selle, 1650 m, *Holdridge* 3032, 3035, May 15, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3157, Dec. 16, 1945; 1369, July 26, 1942. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 597, Feb. 21, 1941. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3094, Aug. 4 - 7, 1945. Jardin Bois, Morne des Commissaires, 1550 m, *Holdridge* 1217, May 15, 1942. Marie Claire, Morne des Commissaires, 1500 m, *Holdridge* 1255, June 9, 1942. South side of Morne Geffrard, *Bartlett* 17673, May 13, 1941. Rotten log, tree ferns, Morne la Selle, *Mackaness* 10, March 18, 1944. Tree fern, Rivière Glace—Jérémie road, *Mackaness* 19, Nov. 1933. — Pantropical, ranging northward to Georgia, Florida and Louisiana.

BARTRAMIACEAE

Leiomela bartramioides (Hook.) Par. Bouche Bouqui, Morne la

Selle, 1750 m, *Holdridge* 1778, Oct. 15, 1943. — Mexico, Guatemala, Costa Rica, South America, Cuba, Jamaica and Haiti.

Philonotis elegantula (Tayl.) Jaeg. (Thériot, 1944). — Haiti, Mexico, Colombia, Ecuador and Argentina.

Philonotis glaucescens (Hornsch.) Par. [Williams, 1930, as *P. tenella* (C. M.) Besch.]. Chardonette, 2000 ft., *Bartlett* 17611, May 11, 1941. Limbe—Plaisance, *Bartlett* 17741, May 24, 1941. Grand Rivière du Nord—Dondon, *Bartlett* 17753, 17754, June 15, 1941. Les Trois Sources, *Bartlett* 17788, 17795, July 8, 1941. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3095, Aug. 4 - 7, 1945. Roadside between Furcy and Kenskoff, *Mackaness* 148, 203, July 18-20, 1944. — Wide in American tropics; southeastern United States north to Kansas.

Philonotis gracillima Angstr. (Williams, 1930). On dirt in ditch, Bayeux, near Port Margot, about sea level, *Nash* 345, Aug. 1903. — Southeastern United States; West Indies; Mexico to northern South America.

Philonotis spaericarpa (Hedw.) Brid. (Williams, 1930). Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17579, 17589, May 8, 1941. Beaumont to Morne Geffrard, *Bartlett* 17657, 17660, May 13, 1941. North of Morne Geffrard, *Bartlett* 17814, July 10, 1941. On bank, Rivière Glace—Jérémie road, *Mackaness* 23, Nov. 1943. Eroding banks, Kenskoff, *Mackaness* 150, Jan. 19, 1944. Steep hillside, mountains above Kenskoff, *Mackaness* 143, Jan. 19, 1944. — Florida; West Indies; Mexico to South America.

Philonotis uncinata (Schwaegr.) Brid. Morne la Selle, 1700 m, *Holdridge* 3006, May 15, 1945. Hammock in pinelands, Savanne Zombí, Morne des Commissaires, *Mackaness* 80, 208, Apr. 28, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 145, July 18 - 20, 1944. Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17591, May 8, 1941. On bank, Rivière Glace—Jérémie road, *Mackaness* 15, Nov. 1943. Steep hillside, mountains above Kenskoff, *Mackaness* 185, Jan. 19, 1944. — Southeastern United States; West Indies; Mexico to South America.

Breutelia brittoniae Ren. & Card. Savanne Zombí Morne des Commissaires, 1580 m, *Holdridge* 2062, Dec. 24, 1944. Mr. Bartram, who kindly confirmed this identification, pointed out that the little pockets usually found on either side of the leaf base are not well marked, a discrepancy which has also been noted among Central American plants. Also he found the setae on mainland specimens 5 mm long, rather than about 15 mm long, as on the mainland. In his opinion, this difference has no great significance. — Costa Rica and Guatemala; Colombia; Haiti.

Breutelia jamaicensis (Mitt.) Jaeg. (*Philonotis haitensis* Ren. & Card., 1890). South of Kenskoff, *Bartlett* 17687, May 18, 1941. — Mexico, Guatemala, Costa Rica, Jamaica and Haiti.

Breutelia picardae (C. M.) Broth. (Müller, 1898, as *Bartramia*).

Described from a Haitian type, this species was erroneously attributed to Jamaica by Brotherus (1924). — Endemic.

Breutelia tomentosa (Sw.) Schimp. On soil and rocks along trail, Furcy, 1300 m, *Leonard* 4503, May 26 - June 15, 1920. — West Indies; Mexico to South America.

ERPODIACEAE

Erpodium domingense (Spreng.) C. M. (Williams, 1930). Bayeux, *Bartlett* 17763, 17782, June 19 - 24, 1941. Corticolous, in hammock, Morne des Commissaires, *Mackaness* 114, Apr. 28, 1944. — West Indies; Texas to Guatemala; Panama.

ORTHOTRICHACEAE

Zygodon campylophyllus C. M. Top of Morne la Selle, 2575 m, *Holdridge* 1889, 1893a, Apr. 24, 1944. Morne Vincent, 2200 m, *Holdridge* 3173, Jan. 2, 1946. On base of pine, above SHADA sawmill no. 1, Morne des Commissaires, *Mackaness* 91, March 19, 1944. Ledge in pine forest, Morne des Commissaires, *Mackaness* 41, Apr. 28, 1944. According to Grout (1946), Thériot's report (1944) of *Z. pentastichus* (Mont.) C. M. from Haiti should be referred here. (*Zygodon domingensis* Thér. of Sto. Domingo also belongs in the synonymy of *Z. campylophyllus*.) — Mexico, Guatemala, Haiti and Sto. Domingo.

Orthotrichum anomalum Hedw. On limestone, SHADA forestry headquarters, Morne des Commissaires, *Mackaness* 61, Apr. 28, 1944 (confirmed by Bartram). — Europe, Asia and Africa; Canada, northeastern United States west to the Rocky Mountains, south to New Mexico; Haiti.

Groutiella husnotii (Schimp.) Crum & Steere (Williams, 1930, as *Macromitrium;* Grout, 1946, as *Craspedophyllum*). — Cuba, Haiti, Puerto Rico, Martinique, Venezuela.

Groutiella mucronifolia (Hook. & Grev.) Crum & Steere (Williams, 1930; Thériot, 1944). Williams' report of *Macromitrium tumidulum* Mitt. probably refers to this species (see Grout, 1946). — Florida; Mexico and Central and South America; Galapagos Islands; West Indies.

Macromitrium cirrosum (Hedw.) Brid. (Britton, 1913; Thériot, 1944). Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3110, Dec. 16, 1945. Morne Vincent, 2200 m, *Holdridge* 3172a, Jan. 2, 1946. — West Indies; Mexico, Guatemala, British Honduras, Costa Rica. Var. *stenophyllum* (Mitt.) Grout. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3062, 3068, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3118, Dec. 16, 1945. On tree, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 28, 82, March 19, 1944. — Cuba, Jamaica, Haiti and Puerto Rico; Guatemala.

Macromitrium homalocron C. M. (*M. haitense* Thér. 1944) — Guatemala, Costa Rica, Jamaica and Haiti.

Macromitrium pentastichum C. M. On tree, hammock in pinelands, road to Savanne Zombí, Morne des Commissaires, *Mackaness* 81, March 17, 1944. — Mexico to South America; West Indies.

Macromitrium stratosum Mitt. On standing pine, Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 592, Feb. 21, 1941. Top of Morne la Selle, 2575 m, *Holdridge* 1888, Apr. 24, 1944. — West Indies; Guatemala and Costa Rica.

Schlotheimia rugifolia (Hook.) Schwaegr. Old log, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 40, 218, March 19, 1944. According to Grout (1946) *S. ciliolata* is a synonym of *S. rugifolia,* and we presume that *S. ciliolata* var. *longifolia* Thér. (1944) can be included here. — Southeastern United States; Mexico to South America; West Indies.

Schlotheimia torquata (Hedw.) Brid. (Thériot, 1944). — West Indies; Mexico, Guatemala, British Honduras; South America.

HELICOPHYLLACEAE

Helicophyllum torquatum (Hook.) Schwaegr. Chardonette, *Bartlett* 17645, May 11, 1941. North of Morne Geffrard, *Bartlett* 17809, 17811a, July 10, 1941. Corticolous in dry woods, Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 103, Jan. 1944. — West Indies; Mexico to South America.

RHACOPILACEAE

Rhacopilum tomentosum (Hedw.) Brid. (Britton, 1913; Williams, 1930). Chardonette, 2000 ft., *Bartlett* 17609, 17612, 17625, 17630, May 11, 1941. South side of Morne Geffrard, *Bartlett* 17675, May 13, 1941. Crest south of Kenskoff, *Bartlett* 17711, May 18, 1941. North of Morne Geffrard, *Bartlett* 17799, 17808, July 10, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 157, July 18 - 20, 1944. Limestone boulder, dry ravine near Saltrou, *Mackaness* 195, March 17, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3044a, 3045a, 3064b, 3065, May 20, 1945. — Common throughout the American tropics, north to Florida and Louisiana.

CRYPHAEACEAE

Acrocryphaea coffeae (C. M.) Par. (Williams, 1930). — Cuba, Jamaica, Haiti, Puerto Rico.

LEUCODONTACEAE

Leucodontopsis geniculata (Mitt.) Crum & Steere. La Vie, *Bartlett* 17681, May 13, 1941. — Florida; West Indies; Mexico to South America; Trinidad.

Pseudocryphaea flagellifera (Brid.) Britt. La Vie, *Bartlett* 17680, May 13, 1941. — Florida; West Indies; Mexico to South America.

PRIONODONTACEAE

Prionodon densus (Hedw.) C. M. (Britton, 1913). Franchon, Morne des Commissaires, 1600 m, *Holdridge* 1688, Aug. 5, 1943. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3053, 3075, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3147, Dec. 16, 1945. Crest south of Kenskoff, *Bartlett* 17721, May 18, 1941. On trees, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 1, March 19, 1944; 65, 246, March 18, 1944. — Mexico to South America; West Indies.

Prionodon haitensis Ren. & Card. (1894; Thériot, 1944). — Endemic.

Prionodon piradae Par. (*P. haitensis* C. M., 1898, *non* Ren. & Card., 1894). — Endemic.

TRACHYPODACEAE

Trachypus viridulus (Mitt.) Broth. (Thériot, 1944). Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3105a, 3160, Dec. 16, 1945. On bark, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 85, March 17, 1944. — Mexico, Guatemala, Costa Rica; Ecuador; Cuba, Jamaica and Haiti.

PTEROBRYACEAE

Calyptothecium duplicatum (Schwaegr.) Broth. [*Neckera porodictyon Ren. & Card.* 1890; Williams, 1930, as *C. moritzii* (Hampe) Broth.]. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3075a, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1600 m, *Holdridge* 1360, July 26, 1942. On bark, hardwood pocket at base of Morne la Selle, *Mackaness* 34, 79, March 18, 1944. Old log, hardwood area above sawmill no. 1, Morne des Commissaires, *Mackaness* 187, 270, March 19, 1944. — Mexico, Guatemala, Costa Rica and Panama; South America; West Indies.

Orthostichidium pentagonum (Hampe & Lor.) C. M. (Arzeni, 1954). — West Indies; Mexico and Central America; Ecuador.

Pireella angustifolia (C. M.) Arzeni (Williams, 1930; Thériot, 1944; Arzeni, 1954). NW. of Marmelade, on tree in ravine, *Nash & Taylor* 1359, Aug. 3, 1905. — West Indies; Central America.

Pireella cymbifolia (Sull.) Card. (Williams, 1930; Arzeni, 1954). — Florida and Louisiana; Mexico, Central America and the West Indies.

Pireella filicina (Hedw.) Card. (Arzeni, 1954). — West Indies; Panama.

Pireella pohlii (Schwaegr.) Card. (Arzeni, 1954). — Florida and Louisiana; Mexico to South America; West Indies.

METEORIACEAE

Squamidium nigricans (Hook.) Broth. Osman, Morne la Selle, 1650 m, *Holdridge* 3022, 3031a, 3041, May 15, 1945. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3073a, May

20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3110a, Dec. 16, 1945. Crest south of Kenskoff, *Bartlett* 17707, May 18, 1941. Wooded summit, south of Kenskoff, *Bartlett* 17727, May 18, 1941. On twigs, hardwood pocket in pinelands route, Savanne Zombí, Morne des Commissaires, *Mackaness* 83, 259, Apr. 28, 1944. — West Indies; Mexico to South America.

Pilotrichella cuspidans Ren & Card. (1890). Crest south of Kenskoff, *Bartlett* 17714, May 18, 1941. On twigs, hardwood pocket in pine forest, Morne des Commissaires, *Mackaness* 5a, March 19, 1944, 26 and 245, March 18, 1944. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3117, 3127a, 3163, Dec. 16, 1945. [It should be noted that *Renauldia subpilifera* Williams (1930), described from Sto. Domingo, is a synonym of *Pilotrichella cuspidans*.] — Haiti and Sto. Domingo; Costa Rica.

Pilotrichella flexilis (Hedw.) Jaeg. (Britton, 1913). Thériot's report (1944) of the variety *gracilis* Broth. & Par. is best ignored as a *nomen nudum*. — West Indies; Mexico to South America.

Pilotrichella hexasticha (Schwaegr.) Jaeg. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3080, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3105, 3151, Dec. 16, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3030, May 15, 1945. Franchon, Morne des Commissaires, 1600 m, *Holdridge* 1688a, Aug. 5, 1943; 1916a, Aug. 4, 1944. Guimbi Galata, Morne des Commissaires, 1800 m, *Holdridge* 1359, July 26, 1942. On branches, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 2, 255, Apr. 28, 1944. On twigs, Rivière Glace—Jérémie road, *Mackaness* 14, Nov. 1943. Roadside between Furcy and Kenskoff, *Mackaness* 160, July 18 - 20, 1944. — West Indies; Costa Rica and Ecuador; probably throughout American tropics under many different names.

Papillaria deppei (Hornsch.) Jaeg. Crest south of Kenskoff, *Bartlett* 17709, May 18, 1941. — Mexico, Central and South America, West Indies.

Papillaria haitensis n. sp. Plantae tenuissimae, rigidae, obscurate flavo-virentes, caespitibus pendulis. Caules secundarii ca. 12 cm longi, abundanter ramosi; ramuli tenues, teretes. Folia sicca appressa, madida late patentia, parce plicata, 0.6 - 0.9 mm longa, ovato-acuminata e basi cordata, marginibus integris, plus minus undulatis; costa invalida, prope medium folii evanida; cellulae laeves, superae breviter rhomboidales, basilares pallidae et elongatae prope costam, alares subquadratae in pluribus seriebus. Caetera ignota.

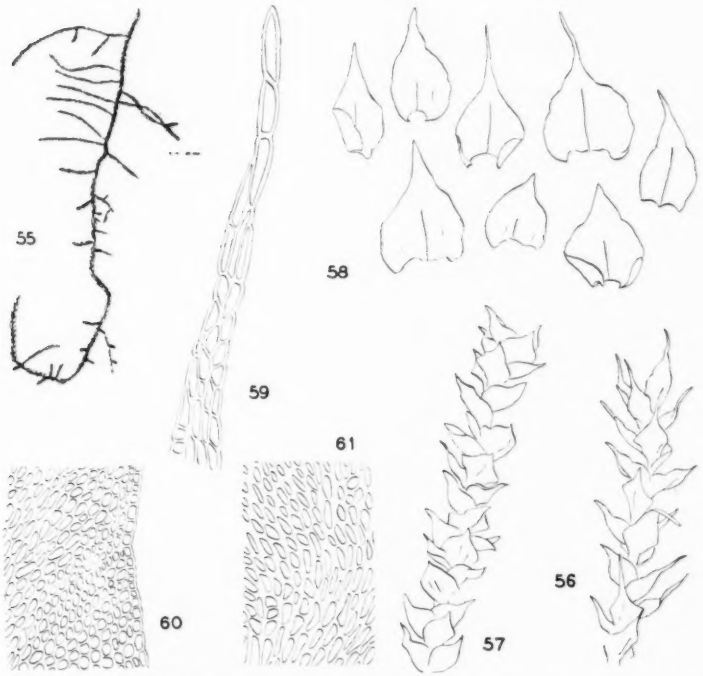
Delicate plants in rigid, dull, yellow-green, pendent masses. Secondary stems about 12 cm long, freely and subpinnately branched, branches slender and terete. Leaves appressed when dry, widely spreading when moist, only slightly plicate, 0.6 - 0.9 mm long, ovate-acuminate from a cordate base; margins subentire, more or less undulate; costa weak, ending at or below midleaf; cells smooth, short

and elliptic or rhombic above, subquadrate in many oblique rows at basal angles, pale and elongate near costa. Sporophyte unknown. (Figs. 55-61.)

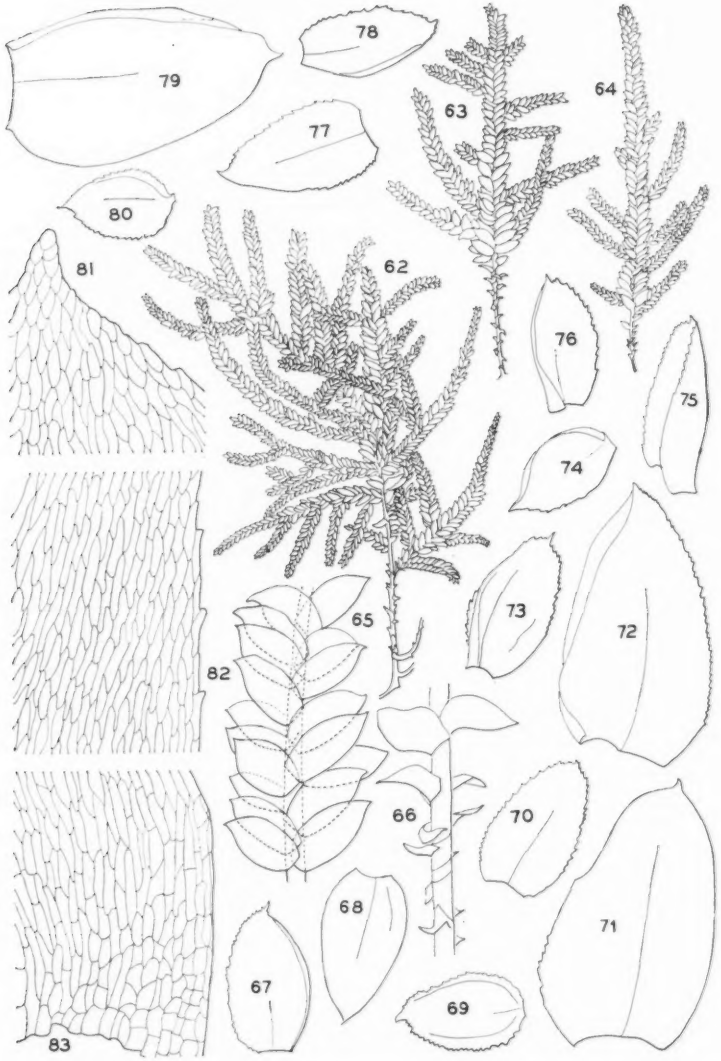
Pendent on twigs and branches, hardwood pocket in pine forest, Morne des Commissaires, *Faith P. Mackaness* 92, Apr. 28, 1944, type (in herb. University of Michigan).

The delicacy of the secondary stems and branches and the pendent habit of growth, as well as the small leaves, are special peculiarities of the species, and the smoothness of the leaf cells is a radical departure from the usual condition in the genus. The shape of the leaves, their slight but distinct plication and their areolation are typical of *Papillaria* and certainly indicate a closer bond to that genus than to any of its allied genera.

Papillaria imponderosa (Tayl.) Broth. A specimen in the herbarium of the N. Y. Botanical Garden [Haiti, *Rev. Bertrand, ex herb.*



Figs. 55-61.—*Papillaria haitensis.* 55.—Habit, ×2. 56.—Stem (near apex), ×17. 57.—Stem (lower portion), ×17. 58.—Representative leaves, ×25. 59.—Apex of leaf, ×220. 60.—Cells above leaf middle, ×220. 61.—Inner basal leaf cells, ×220.



Figs. 62-83.—*Porotrichum squarrosum*. 62-64.—Habit sketches, 62, ×3; 63, ×3; 64, ×2. 65—Axis of frond, ×13. 66.—Portion of stipe, ×13. 67-80.—Leaves, ×25. 81.—Cells at apex of leaf, ×220. 82.—Cells of upper third of leaf, ×220. 83.—Basal leaf cells, ×220.

Renauld as *P. oerstediana* (C. M.) Jaeg.] can be referred here. — Cuba, Jamaica and Haiti; Mexico to South America.

Papillaria nigrescens (Hedw.) Jaeg. [Britton, 1913; Williams, 1930, Thériot, 1944, as *P. appressa* (Hornsch.) Jaeg.]. Chardonette, *Bartlett* 17617, 17644, May 11, 1941. La Vie, *Bartlett* 17679, May 13, 1941. Citadelle, *Bartlett* 17731, May 22, 1941. Plaisance—Pilate, *Bartlett* 17751, 17752, June 15, 1941. North of Morne Geffrard, *Bartlett* 17807, July 10, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 159, 162, July 18 - 20, 1944. — Florida and Louisiana; West Indies; Mexico to South America; China.

Papillaria penicillata (Dozy & Molk.) Broth. (Thériot, 1944, as *P. squamatula* C. M.). Crest south of Kenskoff, *Bartlett* 17710, May 18, 1941. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 87, 251, March 19, 1944, 3, Apr. 28, 1944. On bark, Rivière Glace—Jérémie road, *Mackaness* 22, Nov. 1943. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3051, May 20, 1945. In addition, a number of Haitian specimens under the name of *P. squamatula* C. M. (*Bertrand, Leonard* 4389 and *Ekman* 7698) were seen at the N. Y. Botanical Garden. A number of synonyms and probable synonyms of *P. penicillata* are given by Crum and Bartram (1958); it might also be mentioned that R. S. Williams misapplied, in the herbarium at least, *Papillaria filipendula* C. M. to other tropical American collections. — Jamaica, Haiti and Sto. Domingo; Panama; Ecuador, Venezuela, Colombia, Brazil and Peru.

Meteorium illecebrum (C. M.) Mitt. (Thériot, 1944). Osman, Morne la Selle, 1650 m, *Holdridge* 3041b, May 15, 1945. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3047a, May 20, 1945. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 90, March 17, 1944. On forest floor in pinelands, Morne des Commissaires, *Mackaness* 78, March 18, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 161, July 18 - 20, 1944. South of Kenskoff, *Bartlett* 17686, 17701, May 18, 1941. — West Indies; Mexico to South America.

Lindigia aciculata (Tayl.) Jaeg. Marie Claire, Morne des Commissaires, 1550 m, *Holdridge* 1257b, June 9, 1942. — Mexico, Guatemala, Panama; South America; Jamaica and Haiti.

Barbella cubensis (Mitt.) Broth. [Thériot, 1944, as *B. diclados* (Schimp.) Broth.] On twigs, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 5, March 19, 1944. This species is rather infrequently collected but apparently widespread in the Carribbean area, as well as on the tropical American mainland. Its synonymy includes *Meteorium diclados* Schimp. and *Neckera filescens* Duby, both described from Mexican collections (types seen). According to Cardot (1911), *B. enervis* (Thw. & Mitt.) Fleisch. of Ceylon and *B. determesii* (Ren & Card.) Fleisch. of India and Japan are not specifically distinct from *B. cubensis*. — Mexico, Guatemala, Peru, Cuba, Haiti.

Meteoriopsis patula (Hedw.) Broth. (Britton, 1913; Williams, 1930). South of Kenskoff, *Bartlett* 17689, May 18, 1941. Ridge south of Kenskoff, *Bartlett* 17700, 17716, May 18, 1941. Wooded summit, south of Kenskoff, *Bartlett* 17730, May 18, 1941. North of Morne Geffrard, *Bartlett* 17802, July 10, 1941. On twigs, Rivière Glace—Jérémie road, *Mackaness* 14a, Nov. 1943. Roadside between Furcy and Kenskoff, *Mackaness* 166, July 18 - 20, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3046, May 20, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3012, 3016, 3031, May 15, 1945. On tree, hardwood area, route to Savanne Zombí, Morne des Commissaires, *Mackaness* 51, 248, March 17, 1944. — Florida; West Indies; Mexico to South America.

PHYLLOGONIACEAE

Phyllogonium fulgens (Hedw.) Brid. (Britton, 1913; Williams, 1930). On bark, Rivière Glace—Jérémie road, *Mackaness* 13, Nov. 1943. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 46, March 19, 1944. — West Indies; Mexico to South America.

NECKERACEAE

Neckeropsis disticha (Hedw.) Kindb. La Vie, *Bartlett* 17678, May 13, 1941. Plaisance—Pilate, *Bartlett* 17747, June 15, 1941. Bayeux, *Bartlett* 17778, June 19 - 24, 1941. Les Trois Sources, *Bartlett* 17790, July 8, 1941. Bark of small tree, hardwood area, Morne la Selle, *Mackaness* 25, March 18, 1944. — Florida; West Indies; Mexico to South America.

Neckeropsis undulata (Hedw.) Reich. (Williams, 1930). Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3096, Aug. 4 - 7, 1945. On tree, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 58, 244, March 18, 1944. On limestone and trees, between Savanne Zombí and Saltrou, *Mackaness* 197, March 18, 1944. — Florida and Texas; West Indies; Mexico to South America.

Homaliodendron decompositum (Brid.) Wagner (*Porotrichum grandidens* C. M., 1898). Between Bodine and Thiote, south of Morne des Commissaires, 800 - 1000 m, *Holdridge* 2029a, Nov. 22, 1944. Osman, Morne la Selle, 1650 m, *Holdridge* 3015, May 15, 1945. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3906c, Aug. 4 - 7, 1945. On bark, hardwood pocket above SHADA sawmill no. 1, Morne des Commissaires, *Mackaness* 27, March 19, 1944. — Mexico and Central America; West Indies.

Pinnatella minuta (Mitt.) Broth. (Williams, 1930). Between Bodeine and Thiote, south of Morne des Commissaires, 800 - 1000 m, *Holdridge* 2029b, Nov. 22, 1944. — Mexico, Costa Rica, Guatemala, Cuba, Haiti.

Porotrichum cobanense C. M. (Wagner, 1951). — West Indies; Mexico; Central America.

Porotrichum fasciculatum (Hedw.) Mitt. (Thériot, 1944, as *Porothamnium;* Wagner, 1951). Guimbi Galata, Morne des Com-

missaires, 1700 - 1800 m, *Holdridge* 3140, Dec. 16, 1945. — West Indies; South America; Costa Rica.

Porotrichum squarrosum (Arzeni) n. comb. *Pireella squarrosa* Arzeni, Amer. Midland Nat. 32: 33. Pl. 20. 1954. In addition to the two specimens cited by Arzeni as type and cotype from Haiti and Sto. Domingo, respectively, we have seen a Haitian collection made by George V. Nash (on a stump, ca. 3000 ft. alt., Marmelade, Aug. 25, 1903, No. 841, at New York Botanical Garden). All three collections are remarkably similar and prove the species to belong to *Porotrichum* rather than in *Pireella*. *Porotrichum squarrosum* resembles *P. plicatulum* Mitt. in size and general aspect and its squarrose stipe leaves, as well as its frond leaves of similar shape and structure. The frond leaves of *P. plicatulum* differ, however, in being distinctly plicate and not particularly concave, with margins plane or nearly so and more coarsely toothed and with a somewhat stronger costa ending in a minute dorsal spine. The essential features of *P. squarrosum* have been illustrated in the accompanying figures (62-83), and reference is made to Arzeni's attractive drawings cited above. It is granted that the plants bear some resemblance to *Pireella* in their small size and frondose habit of branching. It is only the younger branches, however, which are terete in the fashion of a *Pireella;* the axis of the frond and the better-developed, longer branches are clearly flattened, as usual in *Porotrichum*. The thin-walled, linear-rhomboidal leaf cells are additional characteristics anomalous in *Pireella*.—Haiti and Sto. Domingo.

LEMBOPHYLLACEAE

Porotrichodendron superbum (Tayl.) Broth. According to Wagner (1951), *Porotrichum crenulatum* C. M. is a probable synonym of this species, and we followed his suggestion in referring Thériot's report (1944) here. *P. superbum* has been collected elsewhere in South America, Costa Rica and Guatemala.

Porotrichodendron bertrandii (Ren. & Card.) Broth. (Renauld & Cardot, 1890, type). Guimbi Galata, Morne des Commissaires, 1700-1800 m, *Holdridge* 3103a, 3132, Dec. 16, 1945; 1276, June 20, 1942. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3050, May 20, 1945. Near Savanne Longue, Morne des Commissaires, *Holdridge* 1692, Aug. 18, 1943. On bark, tree fern forest, Morne la Selle, *Mackaness* 190, March 18, 1944. Forestry headquarters, Morne des Commissaires, *Mackaness* 190, March 1944. — Mexico and Haiti.

Rigodium toxarion (Schwaegr.) Schimp. Osman, Morne la Selle, 1650 m, *Holdridge* 3023, May 15, 1945. Hardwood area in pinelands, on bark, Morne des Commissaires, *Mackaness* 44, March 19, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 214b, July 18 - 20, 1944. — Haiti and Sto. Domingo; Ecuador and Colombia.

PILOTRICHACEAE

Pilotrichum affine (Hook.) C. M. Osman, Morne des Commis-

saires, 1650 m, *Holdridge* 3025, May 15, 1945. Guimbi Galata, Morne des Commissaires, *Holdridge* 3114, Dec. 16, 1945. On tree ferns, hardwood area, Morne des Commissaires, *Mackaness* 4, 191, 252, March 19, 1944.— Cuba, Jamaica, Haiti and St. Vincent.

Pilotrichum lophophyllum Sull. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3096b, Aug. 4 - 7, 1945. — Cuba, Haiti, Sto. Domingo and Puerto Rico.

Pilotrichum mucronatum Mitt. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3088, Aug. 4 - 7, 1945. — Jamaica and Haiti; Costa Rica.

Pilotrichidium leonii (Thér.) Crum & Bartr. Williams report (1930) of *Callicostella subfissidentoides* (Schimp.) Broth. belongs here (see Crum & Bartram, 1958). — Cuba, Jamaica and Haiti.

HOOKERIACEAE

Daltonia longifolia Tayl. (Bartram, 1931). — West Indies; Mexico and Guatemala; South America; Galapagos Islands.

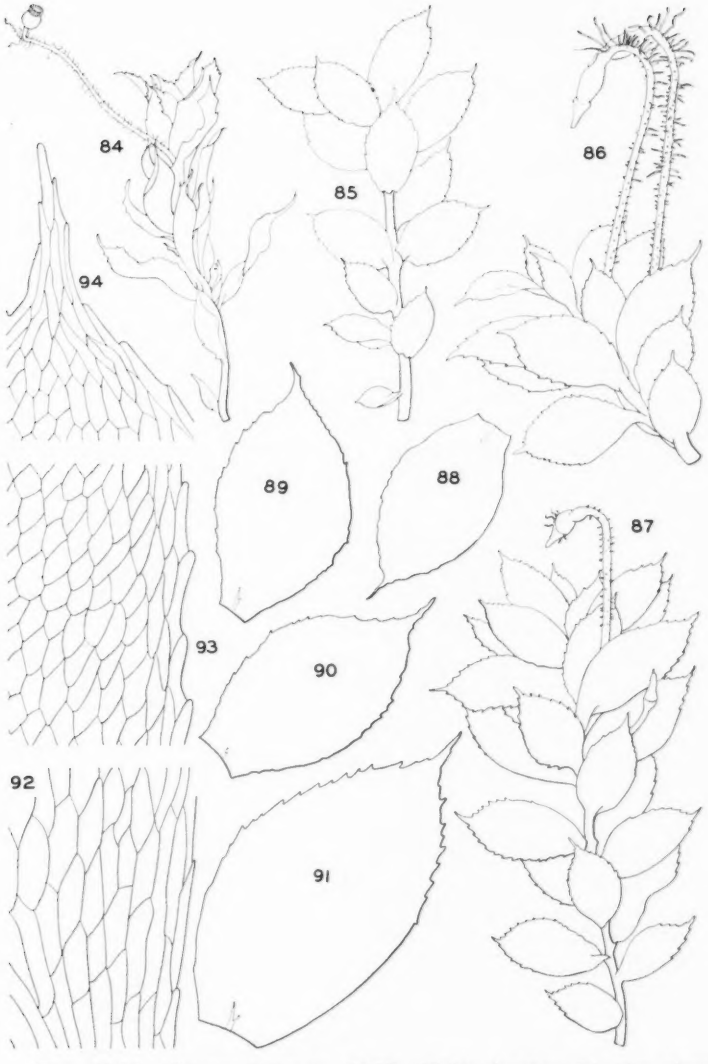
Leskeodon cubensis (Mitt.) Thér. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3145a, Dec. 16, 1945. — Cuba, Haiti, Puerto Rico, Grenada and Trinidad.

Leskeodon parvulus (Schimp.) Broth. On tree, Petit Borgne to Mt. Casse, *Nash* 521, Aug. 16, 1903 (det. Bartram). — Guadeloupe, Dominica, Haiti.

Adelothecium bogotense (Hampe) Mitt. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3067, May 20, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3123, Dec. 16, 1945. Hardwood area in pinelands, SHADA area, Morne des Commissaires, *Mackaness* 219, March 1944. — Mexico, Guatemala, Honduras and Costa Rica; South America; West Indies.

Eriopus haitensis n. sp. Plantae graciles, plus minus nitentes, albidae vel flavo-virentes. Caules ascendentes, simplices vel furcati, ca. 1 cm alti, planati. Folia complanata, sicca rigida et aliquantum contorta, asymmetrica, dorsalia et ventralia dense et oblique appressa, lateralia erecto-patentia, 2-2.2 mm long, ovalia vel oblongo-ovata, abrupte brevi-acuminata, dimidio superiore serrata; costa invalida et brevissima, furcata; cellulae laxae, parietibus tenuibus, ovales vel sexangulares, laeves, basilares elongatae, marginibus in 1-2 seriebus pallidae et longiores limbos pallidos formantes. Autoicus. Seta 2-4 mm longa, viridi-albida, plus minus crassa, infime spinosa, supra setosa. Capsula parva, horizontalis vel subpendens, ovalis; operculum conico-rostratum. Calyptra parva, mitrata, pallida, laevis, basi ciliata.

Slender plants in lax, whitish or yellow-green, moderately shining mats. Stems ascending, simple or forked, about 1 cm high, rhizoidous at base, complanate-foliate. Leaves stiff and somewhat contorted when dry, asymmetric, ventral and dorsal densely and obliquely appressed, lateral vertically spreading, 2-2.2 mm long, oval to ovate-oblong, abruptly short-acuminate, serrate in upper half; costa very



Figs. 84-94.—*Eriopus haitensis*. 84-87.—Habit sketches; 84 (dry plant), ×8; 85, ×10; 86, ×11; 87, ×8. 88-91.—Leaves, ×25. 92.—Cells at base of leaf, ×110. 93.—Upper leaf cells, ×110. 94.—Leaf apex, ×110.

short and weak, forked; cells lax and thin-walled, oval-hexagonal, smooth, longer at base, elongate in 1-2 rows at margins forming a pale border. Autoicous; perigonia near the perichaetia which are aggregated. Setae 2-4 mm long, greenish-white, rather fleshy, spinose below, setose above. Capsules small, horizontal to nearly pendent, oval; operculum conic-rostrate. Calyptra small, mitrate, little longer than the operculum, pale, smooth, ciliate at base. (Figs. 84-94.)

Guimbi Galata, Morne des Commissaires, 1700 - 1800 m alt., *Leslie R. Holdridge* 3124a, 3150a (type), Dec. 16, 1945 (in herb. University of Michigan).

The leaves are more nearly ovate, shorter-acuminate and less strongly bordered than those of *E. setigerus* Mitt., and thus resemble those of *E. mniadelphus* Spruce *ex. Mitt.*, which has longer stems and longer leaves, as well as coarser marginal teeth. This is the first report of the genus from Middle America, although several species are known from South America.

Hookeria acutifolia Hook. Moist banks, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 32, 132a, 219a, March 19, 1944. On rocks in ravine, Mt. Casse, about 3500 ft., *Nash* 531, Aug. 16, 1903. — Scattered in eastern United States; West Indies; Guatemala and Costa Rica; South America; India; Ceylon and Java.

Cyclodictyon albicans (Hedw.) Broth. (Williams, 1930). Guimbi *Galata, Morne des Commissaires*, 1700 - 1800 m, *Holdridge* 3162, Dec. 16, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3036, May 15, 1945. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 53, 257, March 19, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 220, 221, July 18 - 20, 1944. — West Indies; Mexico to South America; Galapagos Islands.

Cyclodictyon albicaule (Schimp.) Broth. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3086b, Aug. 4 - 7, 1945. — Cuba, Haiti, Puerto Rico, Guadeloupe, Martinique.

Cyclodictyon obliquicuspis (C. M.) Crum & Bartr. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3124, Dec. 16, 1945. — Jamaica and Haiti.

Cyclodictyon riparium (Mitt.) Broth. Roadside between Furcy and Kenskoff, *Mackaness* 211, July 18 - 20, 1944. — Jamaica, Haiti, Puerto Rico; South America.

Cyclodictyon varians (Sull.) Broth. Bouche Bouqui, Morne la Selle, 1750 m, *Holdridge* 1780a, 1781a, Oct. 15, 1943. — Florida; West Indies.

Callicostella berteriana (C. M.) Broth. Base of tree near Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 101, Nov. 1943. — Sto. Domingo and Haiti.

Callicostella colombica Williams. Known otherwise only from the type collection from Colombia, this species, unknown to us, was reported by Williams (1930) as "sterile but apparently this." In our experience few species of *Callicostella* can be named with certainty in the absence of sporophytes, many not even then!

Callicostella depressa (Hedw.) Jaeg. (Britton, 1913; Williams, 1930). Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3086, Aug. 4 - 7, 1945. On bark, Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 102, Dec. 1934. On bark, Rivière Glace-Jérémie road, *Mackaness* 16, Nov. 1943. Vicinity of large springs at source of Rivière Tissier, Grand'Anse valley, near Mare Franc, 6 km SW. of Jérémie, *Bartlett* 17573, May 6, 1941. — West Indies; Trinidad and British Guiana; British Honduras.

Hookeriopsis hypniformis (Hook.) Jaeg. Pic Macãyo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 602, Feb. 21, 1941. — Guadeloupe and Haiti.

Hookeriopsis obsoletinervis Thér. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3158, Dec. 16, 1945. — Cuba, Haiti, Puerto Rico.

Lepidopilum amplirete (Sull.) Mitt. (Williams, 1930). — Cuba and Haiti.

Lepidopilum intermedium (C. M.) Mitt. Osman, Morne la Selle, 1650 m, *Holdridge* 3042, May 15, 1945. — Cuba, Haiti and Trinidad; British Guiana, Ecuador and Bolivia.

Lepidopilum polytrichoides (Hedw.) Brid. (Britton, 1913). Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3091, Aug. 4 - 7, 1945. On rocks in gully, Port Margot to Correil, *Nash* 251, Aug. 8, 1903. — West Indies; Mexico to South America.

Lepidopilum robustum Mitt. (Thériot, 1944, as *L. cladorhizans* Besch. forma?). On tree, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 86, March 17, 1944. — Cuba, Jamaica, Haiti, Puerto Rico and Guadeloupe; South America.

Crossomitrium orbiculatum C. M. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3084a, Aug. 4 - 7, 1945. — Haiti, Puerto Rico, Dominica, Montserrat, Guadeloupe, Martinique and Trinidad.

Crossomitrium sintenisii C. M. (Williams, 1930). — Cuba, Jamaica, Haiti, Puerto Rico, Dominica, Guadeloupe and Martinique.

Hypnella filiformis (Hook. *ex* Spreng.) Jaeg. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3129, 3130a, 3139, 3149, Dec. 16, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3010, May 15, 1945. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 601, Feb. 21, 1941. On bark, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 77, March 19, 1944. — West Indies.

Stenodictyon pallidum Britt. *ex* Crum & Steere (1956). Hardwood forest, 1650 m, Osman, Morne la Selle, *Holdridge* 3017, May 15, 1945. — Cuba, Haiti and Puerto Rico.

Rhynchostegiopsis flexuosa (Sull.) C. M. Rivière Glace, Morne la Hotte, 800 - 1000 m. *Holdridge* 3094, Aug. 4 - 7, 1945. — Cuba, Jamaica, Haiti, Puerto Rico, Dominica and Guadeloupe; Mexico, Guatemala, Honduras and Costa Rica.

LEUCOMIACEAE

Leucomium compressum Mitt. Rivière Glace — Morne la Hotte, 800 - 1000 m, *Holdridge* 3086a, Aug. 4 - 7, 1945. — West Indies; Trinidad; northern South America.

HYPOPTERYGIACEAE

Hypopterygium tamariscinum (Hedw.) Brid. (Britton, 1913). Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3135, Dec. 16, 1945. Franchon, Morne des Commissaires, 1600 m, *Holdridge* 1687, Aug. 5, 1943. Rotting logs under tree ferns, Morne des Commissaires, *Mackaness* 6, March 19, 1944. — West Indies; Mexico to South America.

FABRONIACEAE

Fabronia ciliaris (Brid.) Brid. On bark in dry woods, Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 104, Dec. 1943. — Eastern North America and southwestern United States to Guatemala; Haiti.

Fabronia polycarpa Hook. North of Morne Geffrard, *Bartlett* 17812, July 10, 1941. — Haiti and Puerto Rico; Panama; South America.

Helicodontium capillare (Hedw.) Jaeg. (Britton, 1913; Williams, 1930). Chardonette, *Bartlett* 17635, May 11, 1941. Citadelle, *Bartlett* 17735, May 22, 1941. Plaisance—Pilate, *Bartlett* 17750, May 15, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 172, 179, July 18 - 20, 1914. Williams (1930) also reported *H. tenuirostre* Schwaegr., a species doubtfully distinct from *H. capillare*. — Cuba, Jamaica, Haiti and Puerto Rico; Mexico, Guatemala and Nicaragua; South America.

THUIDIACEAE

Anomodon rostratus (Hedw.) Schimp. On bank, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 88, March 17, 1944. On boulder, mountains above Kenskoff, *Mackaness* 153, Jan. 19, 1944. On limestone, dry ravine near Savanne Zombí, *Mackaness* 70, March 18, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 210, July 18-20, 1944. — Europe and Asia; eastern North America; Arizona to Guatemala; Cuba, Jamaica, Haiti and Bermuda.

Haplocladium microphyllum (Hedw.) Broth. Williams, 1930, as "*Haplodontium*"). Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17588, May 8, 1941. Chardonette, 2000 ft., *Bartlett* 17612, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17659, May 13, 1941. Bayeux, *Bartlett* 17773, June 19 - 24, 1941. North of Morne Geffrard, *Bartlett* 17805, July 10, 1941. Marie Claire, Morne des Commissaires, 1550 m, *Holdridge* 1257a, June 9, 1942. Roadside between Furcy and Kenskoff, *Mackaness* 156, July 18 - 20, 1944. On rock, SHADA headquarters, Morne des Commissaires, *Mackaness* 194,

March 1944. — West Indies; eastern United States; Mexico to South America; Europe; Asia.

Thuidium involvens (Hedw.) Mitt. Forestry headquarters, pinelands, Morne des Commissaires, *Mackaness* 253, March 1944. Vicinity of large springs at source of Rivière Tissier, Grand'Anse valley near Mare Franc, 6 km SW. of Jérémie, *Bartlett* 17572, May 6, 1941. Bayeux, at mouth Rivière de Port Margot, between Cap Haitien and Le Borgne, in old rubber plantation within 20 ft. of sea level, *Bartlett* 17781, June 19 - 24, 1941. — Florida; West Indies; Mexico to South America.

Thuidium minutulum (Hedw.) BSG. (Thériot, 1944, as *T. wrightii* Jaeg.). Forestry headquarters, pinelands, Morne des Commissaires, *Mackaness* 254, March 1944. Hardwood forest near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3055, May 20, 1945. On fallen, rotten log, 1500 m, Morne Carotte, Morne la Selle, *Holdridge* 1300, June 22, 1942. — Wide in eastern United States; Mexico and Guatemala; West Indies; Bermuda; South America; Europe.

Thuidium schistocalyx (C. M.) Mitt. Chardonette, *Bartlett* 17620, 17622, 17643, May 11, 1941.— Florida, West Indies; Mexico to northern South America.

Thuidium urceolatum Lor. (Williams, 1930, as *T. acuminatum* Mitt.; Thériot, 1944, as *T. acuminatum* Mitt. and *T. antillarum* Besch.). Ravine, NW. of Marmelade, on rock, 2170 ft., *Nash* & *Taylor* 1339, Aug. 3, 1905. On tree, Petit Borgne to Mt. Casse, 3000 ft., *Nash* 514a, Aug. 16, 1903. On tree, Plaisance—Marmelade, about 2500 ft., *Nash*, 660, Aug. 23, 1903. Near Constant, east of Aux Cayes, Massif de la Hotte, on rocks, ca. 1100 m, *Ekman* 783, Sept. 5, 1917. Marigot, in Trou-Djinn, near Rivière Chotard, Massif de la Selle, ca. 1950 m, *Ekman* 8016, Apr. 15, 1927. On rock, summit SW. of town, Morne Chavary, vicinity of St. Louis du Nord, *Leonard* 14464, 14476e, March 30 - Apr. 7, 1929. On rock, Haut Pitou summit, vicinity of Bassin Bleu, 630 - 1500 m, *Leonard* 15162, Apr. 14-27, 1929. Damp rocks and humus, side of ravine, vicinity of Furcy, Morne de Wizan, about 1300 m, *Leonard* 4421, 4628, 4694, 4715, May 20 - June 15, 1920. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3142a, Dec. 16, 1945. Petite Source to Barassa, Morne des Commissaires, 1500 m, *Holdridge* 1942a, Sept. 7, 1944. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3098, Aug. 4 - 7, 1945. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 1692a, Aug. 18, 1943. Pic Macayo, Morne la Hotte, 5500 - 7500 m, *Holdridge* 600, 604, Feb. 21, 1941. On logs, Rivière Glace—Jérémie road, *Mackaness* 20, Nov. 1943. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 35, March 19, 1944. Chardonette, *Bartlett* 17632, May 11, 1941. South side of Morne Geffrard, *Bartlett* 17674, May 13, 1941. North of Morne Geffrard, *Bartlett* 17798, July 10, 1941. Beaumont to Morne Geffrard, *Bartlett* 17658, May 13, 1941. Thériot's report of

Thuidium antillarum Besch., which he admitted to be questionable, clearly belongs to this species. *Thuidium urceolatum* (including *T. acuminatum* Mitt. as a synonym) is clearly differentiated from *T. antillarum* in having single papillae on the leaf cells and stem leaves considerably enlarged and slenderly long-acuminate; *T. antillarum,* on the other hand, has smaller, gradually short-acuminate stem leaves and several fine papillae per leaf cell. In gross aspect *T. urceolatum* resembles *T. delicatulum* (Hedw.) Mitt., but the form of the stem leaves and the much shorter, blunter papillae are distinctive. — West Indies; Trinidad, British Guiana, Venezuela.

AMBLYSTEGIACEAE

Campylium chrysophyllum (Brid.) Bryhn. Morne Vincent, *Holdridge* 3168, Jan. 2, 1946. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3072, 3073, May 20, 1945. Steep hillsides, mountains above Kenskoff, *Mackaness* 151, Jan. 19, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 169, July 18-20, 1944. South of Kenskoff, *Bartlett* 17693, May 18, 1941. Crest south of Kenskoff, *Bartlett* 17702, May 18, 1941. — Europe, Asia, Canada, eastern United States, southwestern United States, to Guatemala; Jamaica and Haiti.

Campylium hispidulum (Brid.) Mitt. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3061, May 20, 1945. — Europe, Asia, Canada and eastern United States, Mexico, Guatemala, Colombia, Haiti and Guadeloupe. Var. *sommerfeltii* (Myr.) Lindb. Guimbi Galata, Morne des Commissaires, 1800 m, *Holdridge* 1291, June 21, 1942 (det. Bartram). Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3064a, May 20, 1945. Roadside between Furcy and Kenskoff, *Mackaness* 168, July 18 - 20, 1944. On forest floor, pinelands, Morne des Commissaires, *Mackaness* 66, Apr. 28, 1944. — Apparently with the range of the species.

Leptodictyum riparium (Hedw.) Warnst. Attached to limestone in mountain stream, Dubois, near Ford Vendettas, *Mackaness* 71, March 20, 1944. — Europe, Africa, Asia; Canada, United States, Mexico and Guatemala; Haiti and Jamaica.

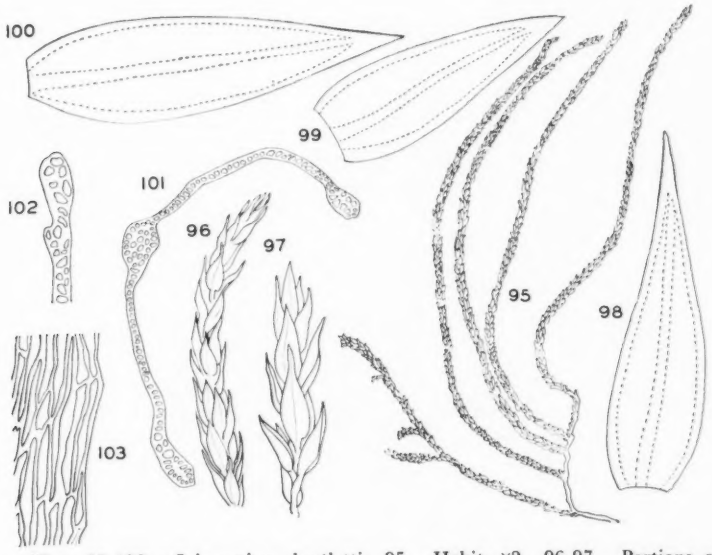
Sciaromium (Limbidium) **bartlettii** n. sp. Plantae aliquantum robustae, caespitibus obscurate flavo-virentibus vel brunneolis. Caules elongati, fasciculato-ramosi; rami erecto-ascendentes, elongati, simplices vel parce ramosi. Folia conferta, suberecta, 2 mm longa, plus minus concava, ovato-lanceolata, sensim acuminata, marginibus planis, sinuosis, ubique limbatis; costa valida, percurrens; cellulae superae obscurae, virentes, lineari-rhomboideae, flexuosae, 51-67 x 8 μ, infime longiores, basi brevi-oblongae in 2-3 seriebus; limbus e cellulis elongatis et bistratosis in 5-10 seriebus formatus, sine cellulis stereidis. Dioicum? Caetera ignota.

Plants rather robust, growing in dull, yellow-green or brownish stiff mats. Stems elongate, fasciculately branched, branches erect-

ascending, elongate, simple or sparsely branched. Leaves crowded, suberect, little changed in drying, 2 mm long, slightly concave, smooth, ovate-lanceolate, gradually acuminate; margins plane, sinuate, bordered all around; costa strong, percurrent, confluent with border at apex, without stereids; upper median cells obscure and green, flexuose, linear-rhomboidal, 51-67 x 8 μ, longer below, short-oblong in 2-3 rows at base, not differentiated at basal angles; cells of border longer and narrower in 5-10 rows, bistratose, not stereid. Apparently dioicous. Sporophyte unknown. (Figs. 95-103.)

Beaumont to Morne Geffrard, 2000 - 2600 ft, alt., Arrondissement de Jérémie (north of divide on road from Les Roseaux to Les Cayes), southern peninsula, *H. H. Bartlett* 17665, May 13, 1941 (type). Attached to stones in swift, cold, clear stream, Rivière Glace between Camp Perrin and Jérémie, *Faith P. Mackaness* 29, Oct. 1, 1943. (Both in herb. University of Michigan).

This species seems distinct from all its tropical and austral relatives in the relatively weak leaf borders which consist of only two or rarely, and only here and there, three layers of cells. In its border, it resembles *S. fryei* Williams of the American Northwest but differs clearly from that species in having much longer leaf cells. The cells of the border are somewhat longer and narrower but otherwise scarcely



Figs. 95-103.—*Sciaromium bartletti*. 95.—Habit, ×2. 96-97.—Portions of branches, 96, ×9; 97, ×15. 98-100.—Leaves, ×25. 101.—Cross-section of leaf, ×220. 102.—Cross-section of leaf margin, ×220. 103.—Upper leaf cells at margin, ×220.

different from those of the lamina. The cells of the lamina are often bistratose near the leaf tips.

Amblystegium varium (Hedw.) Lindb. Bark of tree subject to inundation by Rivière Glace between Camp Perrin and Jérémie, *Mackaness* 31, Oct. 1. 1943. — Bermuda, Haiti, Europe, Asia, Canada southward to Guatemala.

BRACHYTHECIACEAE

Pleuropus leskeoides (Hook.) Steere. Near Mare Sal, Morne des Commissaires, 1600 m, *Holdridge* 1377, July 28, 1942. Top of Morne la Selle, 2575 m, *Holdridge* 1893, Apr. 24, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1500 m, *Holdridge* 3054, 3059, May 20, 1945. On bark, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 52, Apr. 28, 1944; 186, March 19, 1944, 198, 238, 265, March 18, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 171, July 18 - 20, 1944. Crest of ridge south of Kenskoff, *Bartlett* 17699, 17715, May 18, 1941. Wooded summit, south of Kenskoff, *Bartlett* 17725, May 18, 1941. Without citing specimens, Britton (1913a) listed Haiti in the distribution of *Pleuropus congestus* (Sw.) Broth. but went on to say that "little is known of this species in modern times." From her statements it seems that the original specimen from which *P. congestus* was described is a mixture of *P. leskeoides* and *Lepyrodontopsis trichophylla* (Hedw.) Broth. (A Puerto Rican report, on the other hand, is based on a specimen of *Hemiragis aurea;* see Crum & Steere, 1958.) — Tennessee and Texas; Mexico to South America; West Indies.

Lepyrodontopsis trichophylla (Hedw.) Broth. (Britton, 1913, as *Clastobryum*). Osman, Morne la Selle, 1650 m, *Holdridge* 3027, May 15, 1945. Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3120, Dec. 16, 1945. On rocks in glen, about 3500 ft., Mt. Casse, *Nash* 533, Aug. 16, 1903. —West Indies; Trinidad to Venezuela.

Brachythecium stereopoma (Spruce *ex* Mitt.) Jaeg. (Williams, 1930; Thériot, 1944, as *B. pseudolaetum* C. M.). Chardonette, 2000 ft., *Bartlett* 17610, 17840, May 11, 1941. North of Morne Geffrard, *Bartlett* 17801, July 10, 1941. South of Kenskoff, *Bartlett* 17698, May 18, 1941. Wooded summit, south of Kenskoff, *Bartlett* 17726, May 18, 1941. Citadelle, *Bartlett* 17740, May 22, 1941. On bark, hardwood pocket in pinelands, Savanne Zombí, Morne des Commissaires, *Mackaness* 84, Apr. 28, 1944. Steep hillside, mountains above Kenskoff, *Mackaness* 177, Jan. 19, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3069, 3070, May 20, 1945. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3184, Jan. 3, 1946. Port Margot to Correil, on stone, about 1800 ft., *Nash* 241, Aug. 8, 1903. *Brachythecium pseudolaetum* C. M., originally described from a Cuban collection which had been misidentified and reported by Sullivant as *Hypnum laetum,* was also reported from Haiti by Thériot (1944). The Cuban type, however,

seems not specifically distinct from *B. stereopoma.* — West Indies; Mexico to South America.

Rhynchostegium serrulatum (Hedw.) Jaeg. (Williams, 1930). Chardonette, *Bartlett* 17629, 17634, May 11, 1941. Crest south of Kenskoff, *Bartlett* 17718, May 18, 1941. On tree, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 97, Apr. 28, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3045b, 3061a, May 20, 1945. Steep hillside, mountains above Kenskoff, *Mackaness* 274, Jan. 19, 1944. The differences between this and *R. frondicola* (C. M.) Jaeg., as well as other tropical American species, should be carefully analyzed. — Eastern United States; Mexico and Guatemala; Cuba, Jamaica, Haiti, Puerto Rico.

Oxyrrhynchium rigescens (C. M.) Crum & Bartr. Thériot's report (1944) of *Rhynchostegium conchophyllum* (Tayl.) Jaeg. belongs here and probably Williams' record (1930) of *O. clinocarpum,* as well. This species seems very close to *O. hians* (Hedw.) Loeske of North America. One of Holdridge's collections (no. 1891, from 2575 m on Morne la Selle) has been referred here, although it would appear to belong equally well with *O. hians.* — Cuba, Jamaica and Haiti.

Platyhypnidium riparioides (Hedw.) Dixon. Beaumont to Morne Geffrard, *Bartlett* 17669, May 13, 1941. Attached to stones in swift cold water of Rivière Glace between Camp Perrin and Jérémie, *Mackaness* 30, Oct. 1, 1943. — Europe, Africa and Asia; Canada to South America; Haiti.

ENTODONTACEAE

Erythrodontium longisetum (Hook.) Par. [Williams, 1930, as *E. cylindricaule* (C. M.) C. M.]. Near Mare Sal, Morne des Commissaires, 1600 m, *Holdridge* 1376, July 28, 1942. Two sterile collections by Ekman, reported by Thériot (1944) as possibly *E. teres* (C. M.) Par., seem to belong here. — Mexico to South America; Haiti and Jamaica.

Erythrodontium squarrosum (C. M.) Par. Roadside between Furcy and Kenskoff, *Mackaness* 212, July 18 - 20, 1944. — Mexico, Guatemala, El Salvador and Costa Rica; South America; Haiti.

Entodon beyrichii (Schwaegr.) C. M. (Williams, 1930). Crest south of Kenskoff, *Bartlett* 17712, May 18, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 147, July 18 - 20, 1944. — Nicaragua and Costa Rica; Brazil, Ecuador, Bolivia and Peru; Cuba and Haiti.

Entodon hampeanus C. M. On bark, hardwood area, base of Morne la Selle, *Mackaness* 39, 193, March 18, 1944. — Mexico to South America; West Indies.

Entodon macropus (Hedw.) Mitt. (Williams, 1930; Thériot, 1944). Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3060, May 20, 1945. Roadside between Furcy and Kenskoff, *Mackaness* 146, July 18 - 20, 1944. Chardonette, 2000 ft., *Bartlett* 17615, 17637, May 11, 1941. — Southeastern United States; Mexico to South America; West Indies; reported from China and Japan.

PLAGIOTHECIACEAE

Stereophyllum cultelliforme (Sull.) Mitt. (Williams, 1930). Plaisance-Pilate, *Bartlett* 17751b, June 15, 1941. Bayeux, *Bartlett* 17777, June 19 - 24, 1941. Les Trois Sources, between Chambellan and Cayaba, *Bartlett* 17790a, 17793b, July 8, 1941. On rocks, mountain slope southeast of town, Morne Colombot, vicinity of St. Louis du Nord, *Leonard* 14304, March 1929. — Mexico, Honduras, Costa Rica and Panama to Peru; West Indies.

Stereophyllum leucostegum (Brid.) C. M. (Williams, 1930). The type of *S. ruderale* (Brid.) Mitt. was collected in "Hispaniola, in ruderalis, *Poiteau*." Brotherus (1924-25) cited the species from Haiti; he had seen no material, however, and probably referred only to the type collection (which may indeed have been Haitian in origin). Brotherus' key separates *S. ruderale* from *S. leucostegum* on the basis of leaf margins plane in the former, recurved in the latter. Grout (1945) said that Mrs. Britton, in notes at the New York Botanical Garden, cited *Hypnum* (Stereodon) *ruderale* Brid. as a synonym of *S. leucostegum*. — Florida; West Indies; Mexico to South America; Trinidad.

Stereophyllum radiculosum (Hook.) Mitt. (Williams, 1930). Chardonette, 2000 ft., *Bartlett* 17616, May 11, 1941. North of Morne Geffrard, *Bartlett* 17813, July 10, 1941. — Florida and Texas; West Indies; Mexico to Paraguay.

Pilosium serrulatum Williams (1930). In his revision of *Stereophyllum* and *Pilosium* Grout (1945) retained *P. serrulatum* but considered it "doubtfully more than a variety of *P. chlorophyllum* with more distinctly serrulate leaves, narrower median leaf cells and more numerous enlarged basal cells." — Endemic.

SEMATOPHYLLACEAE

Heterophyllium affine (Hook.) Fleisch. (Thériot, 1944). — Europe and Asia; mountains of southeastern United States; Mexico, Guatemala and Colombia; Haiti and Jamaica.

Meiothecium tenerum Mitt. On pine trunk, Morne des Commissaires, 1600 m, *Holdridge* 1358, July 24, 1942. On bark of fallen pine, Morne des Commissaires, *Mackaness* 91, 269, March 19, 1944. — Mexico, British Honduras and Costa Rica, Bolivia, Argentina and Brazil; Haiti.

Pterogoniopsis cylindrica C. M. forma (Thériot, 1944). We are very doubtful of this report, because of the improbable disjunction between Argentina (or Uruguay) and Haiti and also because of the morphologic discrepancies mentioned by Thériot. (The type locality of this species is in some question; Müller's citation reads "Argentina uruguayensis," meaning perhaps some locality near the border which may have been in dispute.)

Sematophyllum admistum (Sull.) Mitt. (Williams, 1930). This record and others from tropical America should be confirmed. Thériot (1939-41), who listed a number of collections from Cuba, where the

type originated, pointed out that Brotherus, in the first edition of the "Musci" in *Die natürlichen Pflanzenfamilien*, had erroneously placed this species in the relationship of *S. sericifolium* Mitt., which is characterized by its narrow, subtubulose leaves with margins incurved above. As we understand it, *S. admistum* has narrow leaves which are flat above. It may be that because of the great influence that Brotherus' keys have long had on the identification of unknowns, some of the reports of *S. admistum* can be referred instead to *S. sericifolium*. — West Indies; northern South America.

Sematophyllum caespitosum (Hedw.) Mitt. [Britton, 1913; Williams, 1930, as *S. loxense* (Hook.) Mitt. and *S. subpinnatum* (Brid.) Britt.]. Plaisance—Pilate, *Bartlett* 17748, June 15, 1941. Bayeux, *Bartlett* 17761, 17769, 17772, 17784, June 19 - 24, 1941. Limbe — Plaisance, *Bartlett* 17743, May 24, 1941. Dry woods, Canapé Verte, above Port-au-Prince, *Mackaness* 284, May 1944. — Wide in tropical America, north to Florida, and perhaps in the tropics of the Old World (Dixon, 1920).

Sematophyllum galipense (C. M.) Mitt. (Williams, 1930). — West Indies; Guatemala, Honduras, Costa Rica; Venezuela, Cocos Island and Trinidad.

Sematophyllum sericifolium Mitt. (Thériot, 1944). Jardin Bois, Morne des Commissaires, 1550 m, *Holdridge* 1217b, May 15, 1942. Near Savanne Longue, Morne des Commissaires, 1550 m, *Holdridge* 1694, Aug. 18, 1943. Top of Guimbi Galata, Morne des Commissaires, *Holdridge* 1800, Oct. 24, 1943. Rac Mediante, Morne des Commissaires, 1600 m, *Holdridge* 1351, July 21, 1942. Guimbi Galata, Morne des Commissaires, 1800 m, *Holdridge* 1363, July 26, 1942, 3100, 3125, 3159, Dec. 16, 1945. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3066, May 20, 1945. Marie Claire, Morne des Commissaires, 1600 m, *Holdridge* 1207, May 14, 1942. On stumps, Osman, Morne la Selle, 1650 m, *Holdridge* 3019, 3040, May 15, 1945. North of Morne Geffrard, *Bartlett* 17806, July 10, 1941. On bark, hardwood pocket in pinelands, Morne des Commissaires, *Mackaness* 95, March 19, 1944. On pine bark, forestry headquarters, Morne des Commissaires, *Mackaness* 260, March 1944. — West Indies; Mexico, Guatemala, British Honduras, Honduras; northern South America.

Sematophyllum xylophyllum Mitt. Bois Contre, near Morne la Selle, Orcutt 8468, March 22, 1929. On standing pine, Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 596, Feb. 21, 1941. —West Indies; Trinidad.

Acroporium acestrostegium (Sull.) Crum & Steere (1956). Vicinity of large springs at source of Rivière Tissier, Grand'Anse Valley, near Mare Franc, 6 km SW. of Jérémie, *Bartlett* 17574, May 6, 1941. In hardwood area in pinelands, Morne des Commissaires, *Mackaness* 188, March 19, 1944. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3043, 3047, May 20, 1945. — Cuba, Haiti and Puerto Rico.

Acroporium pungens (Hedw.) Broth. (Britton, 1913; Thériot, 1944). Belle Aire, Morne la Selle, 1600 m, *Holdridge* 1332, June 5, 1942. — West Indies; Guatemala to South America.

Taxithelium planum (Brid.) Mitt. (Williams, 1930). Vicinity of large springs at source of Rivière Tissier, Grand'Anse Valley, near Mare Franc, 6 km SW. of Jérémie, *Bartlett* 17570, 17574 (in mixture), May 1941. Cayaba to Moron, on road from Dame Marie to Jérémie, *Bartlett* 17595, May 8, 1941. Limbe—Plaisance, *Bartlett* 17742, May 24, 1941. Les Trois Sources, *Bartlett* 17794, July 8, 1941. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3089, Aug. 4 - 7, 1945. — Florida; West Indies; Mexico to South America.

HYPNACEAE

Hypnum holdridgei n. sp. Plantae parvae, pallido-luteae. Caules erecti, irregulariter ramosi; ramuli curvati. Folia caulina et ramulina similia, concava, appressa, apicibus secundis, 1 mm longa, ovato-acuminata, prope apices serrulata; costa nulla; cellulae parietibus tenuibus, supra lineari-rhomboideae, 6-10 : 1 (48-64 × 6-8 μ), basi flavae, paucae quadratae in regionibus alaribus. Caetera ignota.

Small, delicate, pale-golden plants growing intermingled with other mosses. Stems erect, irregularly branched, branches curved. Stem and branch leaves similar, concave, appressed and secund at tips, 1 mm long, ovate-lanceolate, acuminate, finely serrulate at tips, ecostate; cells thin-walled, linear-rhomboidal above, 6-10: 1 (48-64 × 6-8 μ), yellow across insertion, alar quadrate in small triangular patches usually 3 rows wide and extending 4-7 cells up margins. Inflorescence and sporophyte unknown. (Figs. 109-111.)

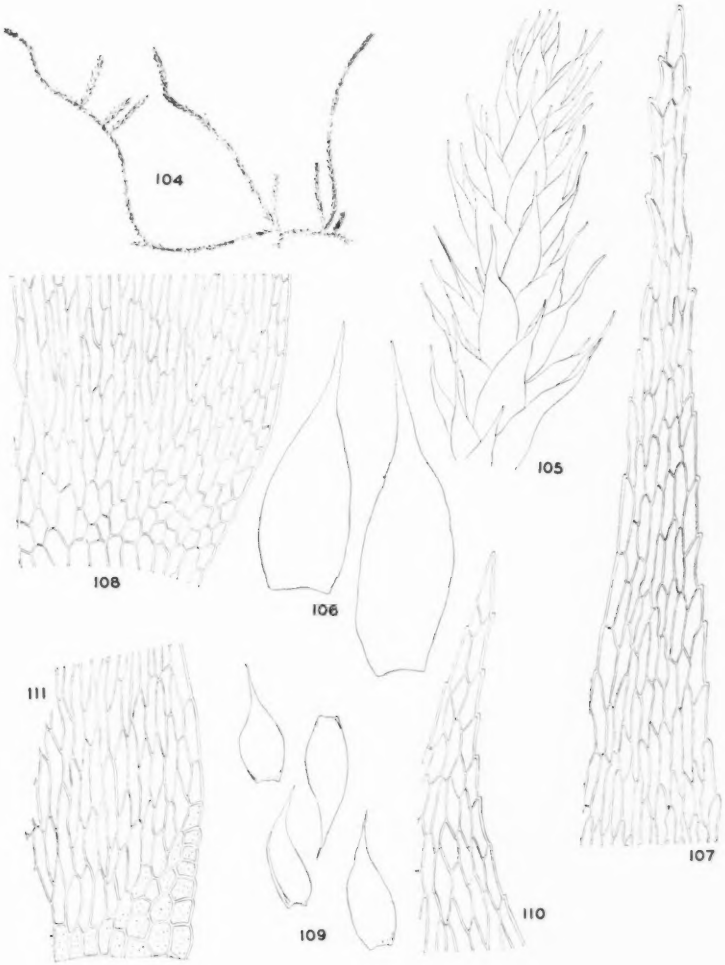
Top of Morne la Selle, 2575 m alt., *Leslie R, Holdridge* 1890a (growing with *Orthodicranum flagellare*), April 24, 1944 (type in herb. University of Michigan.)

The actual relationship of *Hypnum holdridgei* may be in some question until fruiting plants can be found. It is similar to *Hypnum reptile* Mx. in general appearance and in the nature of the alar cells, but the golden coloration of the leaf insertion, the longer median cells and weak marginal teeth limited to the tips of the leaves are distinctive. It is also very suggestive of *Pylaisiadelpha,* a genus of Sematophyllaceae, but in that genus, the extreme alar cells are more inflated, the leaves end in longer acumina, and the margins are more coarsely serrulate.

Hypnum polypterum (Mitt.) Broth. Roadside between Furcy and Kenskoff, *Mackaness* 272, July 18 - 20, 1944. — Mexico and Central America; Cuba, Haiti, Jamaica and Guadeloupe.

Ectropothecium apiculatum (Hornsch.) Mitt. On rocks in ravine, Marmelade, about 3000 ft., *Nash* 764, Aug. 25, 1903. — Mexico to South America; West Indies.

Ectropothecium globitheca (C. M.) Mitt. Beaumont to Morne Geffrard, *Bartlett* 17653, May 13, 1941. South side of Morne Geffrard, *Bartlett* 17676b, May 13, 1941. North of Morne Geffrard, *Bart-*



Figs. 104-108.—*Isopterygium robusticaule*. 104.—Habit, ×3.5. 105.—Portion of branch, ×12. 106.—Branch leaves, ×22. 107.—Cells at apex of leaf, ×191. 108.—Basal leaf cells, ×191. Figs. 109-111.—*Hypnum holdridgei*. 109.—Leaves, ×25. 110.—Upper cells of leaf, ×223. 111.—Basal marginal cells of leaf, ×223.

lett 17800, July 10, 1941. Pic Macayo, Morne la Hotte, 5500 - 7500 ft., *Holdridge* 601a, Feb. 21, 1941. — West Indies; Central and South America.

Isopterygium micans (Sw.) Broth. (Williams, 1930). There has been considerable confusion between *I. micans* and *I. tenerum* (Sw.) Mitt. (see Crum & Bartram, 1956), and whether *I. micans* actually occurs in tropical America is open to question. It has been recorded from a number of places in the West Indies, as well as in Trinidad and Brazil, in addition to the eastern United States.

Isopterygium robusticaule Bartr. At 800 - 1000 m, Rivière Glace, Morne la Hotte, *Holdridge* 3090, Aug. 4-7, 1945. This species is distinctive in its general aspect, suggestive of a *Pleuropus;* it seems rather anomalous in *Isopterygium* because of its robust stature, elongate, flexuose stems and particularly its erect or ascending branches which are not at all flattened. In the absence of sporophytes, however, no other genus presents itself as a more logical category to which the species might be assigned. The essential features of this interesting species are presented in Figs. 104-108. — Guatemala, Jamaica and Haiti.

Isopterygium tenerum (Sw.) Mitt. (Britton, 1913; Williams, 1930; Thériot, 1944). Osman, Morne la Selle, 1650 m, *Holdridge* 3008a, 3009, 3014, May 15, 1945. Rac Mediante, Morne des Commissaires, 1600 m, *Holdridge* 1353, July 21, 1942. Guimbi Galata, Morne des Commissaires, 1800 m, *Holdridge* 1800a, Oct. 24, 1943, 3145, Dec. 16, 1945. Dry woods, Canapé Verte, above Port-au-Prince, *Mackaness* 285, May 1944. Plaisance—Pilate, *Bartlett* 17749, June 15, 1941. Bayeux, *Bartlett* 17756, 17758a, June 19 - 24, 1941. On bark, dry woods, Source Turgeau, Morne Hôpital, above Port-au-Prince, *Mackaness* 105, Jan. 1944. — West Indies; Mexico to northern South America; Trinidad; Bermuda (Britton, 1913).

Taxiphyllum planissimum (Mitt.) Broth. (Williams, 1930). Chardonette, *Bartlett* 17636, 17638, May 11, 1941. Les Trois Sources, *Bartlett* 17792, July 8, 1941. Roadside between Furcy and Kenskoff, *Mackaness* 158, July 18 - 20, 1944. —Florida; West Indies; Mexico to South America.

Vesicularia crassicaulis (Mitt.) Broth. (Williams, 1930). Chardonette, *Bartlett* 17641, May 11, 1941. Beaumont to Morne Geffrard, *Bartlett* 17662, May 13, 1941. — Florida; Costa Rica; Cuba, Jamaica and Haiti.

Vesicularia vesicularis (Schwaegr.) Broth. (Williams, 1930). Citadelle, *Bartlett* 17734, May 22, 1941. — Florida; West Indies; Mexico to South America.

Ptilium orthothecium Thér. (1944). — Endemic.

Mittenothamnium diminutivum (Hampe) Britt. [Williams, 1930, as *Microthamnium diminutivum* (Hampe) Jaeg. and *M. thelistegum* (C. M.) Mitt.; Thériot, 1944, as *Microthamnium diminutivum* and *M. perspicuum* (Hampe) Jaeg.]. Chardonette, *Bartlett* 17618, May 11, 1941. South side of Morne Geffrard, *Bartlett* 17676, May 13,

1941. North of Morne Geffrard, *Bartlett* 17804, July 10, 1941. Marie Claire, Morne des Commissaires, 1550 m, *Holdridge* 1257, June 9, 1942. Forestry headquarters, pinelands, Morne des Commissaires, *Mackaness* 256, March 1944. Fleischer (1908) recognized both *M. perspicuum* and *M. thelistegum* and referred *M. diminutivum*, the most commonly encountered member of the genus in tropical America, to *Ctenidium*. Britton (1914) considered this disposition of *M. diminutivum* to be in error and included in its synonymy both *M. perspicuum* and *M. thelistegum*. — Florida; West Indies; Mexico to South America; South Africa (as *M. thelistegum, fide* Fleischer).

Mittenothamnium ekmanii (Thér.) n. comb. *Microthamnium ekmanii* Thér., Travaux Bryol. 2(Rev. Bryol. et Lichénol. 14) : 22. 1944. A new combination is necessary because *Microthamnium* Mitt. of 1869 is antedated by *Microthamnium* Nägeli of 1846, a name applicable to a genus of algae. — Endemic.

Mittenothamnium minusculifolium C. M. On bark, hardwood area in pinelands, above sawmill no. 1, Morne des Commissaires, March 19, 1944. Mr. Bartram, who supplied the name for this specimen, described it as a "small edition of *M. reptans* with the stipe leaves of the same shape but less than half as large." Fleischer (1908) treated this species, so suggestive of a *Thuidium* at first glance, as a variety of *M. reptans* (Hedw.) Card., and Britton (1914) included it (as "*minusculum*," an obvious misspelling) in the synonymy of *M. reptans*. — Mexico, Guatemala and Costa Rica; Jamaica, Haiti and Guadeloupe.

Mittenothamnium reptans (Hedw.) Card. (Williams, 1930, as *Microthamnium*). Guimbi Galata, Morne des Commissaires, 1700 - 1800 m, *Holdridge* 3133, Dec. 16, 1945. Near Savanne Jean Louis, Morne des Commissaires, 1550 m, *Holdridge* 3049, 3052, 3058, May 20, 1945. Osman, Morne la Selle, 1650 m, *Holdridge* 3018, May 15, 1945. Bouche Bouqui, Morne la Selle, 1750 m, *Holdridge* 1779a, Oct. 15, 1943. Rivière Glace, Morne la Hotte, 800 - 1000 m, *Holdridge* 3087, Aug. 4 - 7, 1945. North of Morne Geffrard, *Bartlett* 17800a, 17803, July 10, 1941. On logs, hardwood area in pinelands, Morne des Commissaires, *Mackaness* 36, 199, March 19, 1944. On stone, Petit Borgne to Mt. Casse, about 2000 ft., *Nash* 515, Aug. 16, 1903. — West Indies; Mexico to South America; South Africa, as var. *pseudoreptans* (C. M.) Dix.

RHYTIDIACEAE

Cryptoneurum acuminatum Thér. & P.-V. (1944). — Endemic.

POLYTRICHACEAE

Atrichum angustatum (Brid.) BSG. var. *muelleri* (Schimp. *ex* Besch.) Bartr. Near Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 1220, May 15, 1942. Roadbank in pinelands, Morne des

Commissaires, Mackaness 96, Apr. 28, 1944; 67a, March 18, 1944. — Mexico, Guatemala, Honduras, Jamaica, Haiti.

Pogonatum tortile P.-B. (*Polytrichum obscuroviridis* [*sic*] C. M.; Britton, 1913; *Williams*, 1930.) Beaumont to Morne Geffrard, *Bartlett* 17650, 17654, 17672, May 13, 1941. South of Kenskoff, *Bartlett* 17690, May 18, 1941. Roadside, Rivière Glace — Jérémie road, *Mackaness* 18, Nov. 1943. Roadside, pinelands, Morne des Commissaires, *Mackaness* 67, March 18, 1944. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3190, Jan. 3, 1946.—West Indies; Mexico to South America.

Pogonatum flexuosum (C. M.) Broth. (*P. ekmani* Thér. 1944; Frye & Duckering, 1946).—Mexico, Guatemala, Costa Rica; Peru; Cuba, Haiti and Jamaica.

Polytrichum antillarum Rich. Marie Claire, Morne des Commissaires, 1600 m, *Holdridge* 1208, May 14, 1942. Osman, Morne la Selle, 1650 m, *Holdridge* 3021, May 15, 1945. Roadside through pinelands, Morne des Commissaires, *Mackaness* 42, March 18, 1944. Roadside between Furcy and Kenskoff, *Mackaness* 202, July 18-20, 1944. South of Kenskoff, *Bartlett* 17682, May 18, 1941. It is doubtful whether *P. antillarum* and *P. juniperinum* can be satisfactorily segregated.—Mexico to South America; West Indies.

Polytrichum juniperinum Hedw. Jardin Bois, Morne des Commissaires, 1600 m, *Holdridge* 3196, Jan. 3, 1946. Forestry headquarters, pinelands, Morne des Commissaires, *Mackaness* 250, March 1944.—Nearly cosmopolitan.

REFERENCES

ANDREWS, A. L. 1950—Studies in the Bryaceae. The Bryologist 53:115-118, 175-180.

ARZENI, C. B. 1954—The Pterobryaceae of southern United States, Mexico, Central America, and the West Indies. Amer. Midland Nat. 52:1-67.

BARTRAM, E. B. 1931—A review of the American species of *Daltonia*. Bull. Torrey Bot. Club 58:31-48.

BRITTON, ELIZABETH G. 1912—Notes on the mosses of Jamaica. The Bryologist 15:28-29.

———1913—Ditrichaceae. N. Amer. Fl. 15:55-67.

———1913a—West Indian mosses. I. Bull. Torrey Bot. Club 40:563-676.

———1914—Notes on nomenclature—XII. The Bryologist 17:7-10.

BROTHERUS, V. F. 1924-25—Musci. *In* Engler & Prantl's Die natürlichen Pflanzenfamilien. Ed. 2. Vol. 10-11. Leipzig.

CARDOT, J. 1911—Coup d'oeil sur la flore bryologique du Mexique. Rev. bryol. 38:97-105.

CORRENS, C. 1899—Untersuchungen über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge. Jena. 472 pp.

CRUM, H. A. 1949—The discovery of fruiting *Gymnostomiella orcutti* in Mexico. The Bryologist 52:208-211.

———1952—*Pseudosymblepharis* in Middle America. *Ibid.* 55:137-142.

——— AND E. B. BARTRAM 1958—A survey of the moss flora of Jamaica. Bull. Inst. of Jamaica, Science Series 8:1-90.

——— AND W. C. STEERE 1956—Puerto Rican Musci. New species and new combinations. The Bryologist 59:246-255.

——— AND ———1957—The mosses of Puerto Rico and the Virgin Islands. N. Y. Acad. Sci. Scientific Survey of Porto Rico and the Virgin Islands. Vol. 7, pt. 4a:395-599.

DIXON, H. N. 1920—*Rhaphidostegium caespitosum* (Sw.) and its affinities. Jour. of Bot. 58:81-89.

FERNALD, M. L. 1931—Specific segregations and identities in some floras of eastern North America and the Old World. Rhodora 33:25-63.

FLEISCHER, M. 1908—Grundlagen zu einer Monographie der Gattung *Stereohypnum* (Hpe.) (*Microthamnium* Mitt. *olim*). Hedwigia 47:271-299.

FRYE, T. C. AND MAE E. DUCKERING 1946—*Pogonatum flexuosum*. The Bryologist 49:141-146.

GROUT, A. J. 1943—Fissidentaceae. No. Amer. Fl. 15(3):167-202.

———1945—A revision of the North American species of *Stereophyllum* and *Pilosium*, with descriptions of some South American species. The Bryologist 48:60-70.

———1946—Orthotrichaceae. No. Amer. Fla. 15A(1):1-61.

MEIJER, W. 1951—The genus *Orthodontium*. Amsterdam. 80 pp.

MÜLLER, C. 1898—Analecta bryographica Antillarum. Hedwigia 37:219-266.

RENAULD, F. AND J. CARDOT 1890—Musci exotici novi vel minus cogniti. I. Bull. Soc. Roy. Bot. Belg. 29(1):161-186.

——— AND ——— 1894—Musci exotici novi vel minus cogniti. VI. *Ibid.* 33(2):109-137.

SCHUCHERT, C. 1935—Historical Geology of the Antillean-Caribbean region. Wiley, New York. 811 pp.

SHARP, A. J. 1939—Taxonomic and ecological studies of eastern Tennessee bryophytes. Amer. Midland Nat. 21:267-354.

———1946. Informe preliminar sobre algunos estudios fitogeográficos efectuados en México y Guatemala. Rev. Soc. Mexicana Hist. Nat. 7:35-44.

———1951. The relation of the Eocene Wilcox flora to some modern floras. Evolution 5:1-5.

THÉRIOT, I. 1939-41—Complement au Catalogue des Mousses de Cuba et revision de plusieurs genres. Mem. Soc. Cubana de Hist. Nat. 13:203-222. Pl. 31-32, 265-280. Pls. 34-35 (1939); 14:349-372. Pl. 54-55 (1940); 15:211-230. Pl. 21 (1941).

———1944—Musci hispaniolenses. Trav. Bryol. 2(Rev. Bryol. et Lichénol. 14):7-25.

WAGNER, K. A. 1951—The Neckeraceae of North America. University of Michigan, Ann Arbor. University Microfilms, 1951, AC-1, no. 2665.

WILLIAMS, R. S. 1913—Dicranaceae. *In* No. Amer. Flora 15(2):77-158.

———1920—Calymperaceae of North America. Bull. Torrey Bot. Club 47:367-396.

———1930—Haitian mosses collected by E. C. Leonard. Jour. Wash. Acad. Sci. 20:173-180.

Geographical Distributions of the American Drosophila affinis Subgroup Species[1]

DWIGHT D. MILLER
University of Nebraska[2]

The *Drosophila affinis* subgroup belongs to the *D. obscura* group of the subgenus *Sophophora* Sturtevant. Except for one European species, *D. helvetica* Burla, 1948, the subgroup consists of eight American species: *D. affinis* Sturtevant, 1916; *algonquin* Sturtevant and Dobzhansky, 1936; *athabasca* Sturtevant and Dobzhansky, 1936; *azteca* Sturtevant and Dobzhansky, 1936; *dobzhanskii* Patterson, 1943; *narragansett* Sturtevant and Dobzhansky, 1936; *seminole* Sturtevant and Dobzhansky, 1936; and *tolteca* Patterson and Mainland, 1944. The closeness of relationship of these species is attested to not only by their morphological similarity but also by the fact that it has been possible in the laboratory to derive certain interspecific hybrids: *athabasca* x *azteca,* both reciprocal crosses (Sturtevant and Dobzhansky, 1936); *algonquin* ♀ x *athabasca* ♂ (Miller, 1939); *affinis* ♀ x *athabasca* ♂ (Miller, 1941); and *azteca* x *tolteca,* both reciprocal crosses (Patterson, 1954). Moreover, female *algonquin-athabasca* hybrids are fertile (Miller, 1941), as are both sexes of hybrids between *tolteca* ♀ ♀ and *azteca* ♂ ♂ (Patterson, 1954).

Since the *affinis* subgroup was first identified (Sturtevant and Dobzhansky, 1936), the distributions of the member species and their incidence in collections have been reported both in reports on cytological and genetic variation in the species, and in reports on *Drosophila* collecting and species distributions — for example, Dobzhansky and Sokolof (1939), Miller (1939), Patterson (1943), Patterson and Wagner (1943), Dobzhansky and Epling (1944), Patterson and Mainland (1944), Novitski (1946), Spiess (1949), Patterson and Stone (1952), Williams and Miller (1952), Levitan (1954), and Buzzatti-Traverso and Scossiroli (1955). These reports (and unpublished data) have not only led to extensions of previously known geographical ranges, but also have given better ideas of the limits of distribution of some of the species and of the relative frequencies of two or more of the species collected together. It is the purpose of this paper to summarize information on the distributions of the American members of the *affinis* subgroup, using published records and the unpublished data of the author and several other collectors.

---

[1] This study was supported by a grant from the National Science Foundation. Parts of this study have also been aided by grants from the University of Nebraska Research Council, the Wolcott Memorial Fund of the University of Nebraska Department of Zoology, and the Long Island Biological Association.

[2] Contribution Number 306 of the Department of Zoology of the University of Nebraska.

Acknowledgements.—The author wishes to thank other workers for the large amount of unpublished collecting data made available for this paper. He is indebted to Dr. W. P. Spencer of the College of Wooster for his extensive Ohio data on the *affinis* subgroup. A major contribution of data was that of Drs. H. L. Carson and H. D. Stalker of Washington University; together they made available a large amount of collecting data from the St. Louis, Missouri, and Gatlinburg, Tennessee, areas. Dr. Stalker furnished his April, 1946, collecting data from the southeastern states and has also sent the author numerous shipments of Drosophilas from his collections elsewhere. Dr. M. R. Wheeler of the University of Texas has also been most generous with collecting data and specimens. Dr. William Heed of the University of Pennsylvania furnished the Nicaraguan strain of *tolteca*, used in testing the South American strains of this species, provided by Dr. Wheeler. The author is also grateful to certain of his students, past and present, for assistance in collecting, examining, and testing specimens: Mr. Stewart Ensign, Mr. Ralph Sulerud, Dr. Leo Weeks, and Mr. David Williamson. The author also wishes to thank several Canadian biologists who provided facilities in Ontario and Quebec in the summer of 1956: Dr. R. S. Bigelow of Macdonald College, Dr. R. O. Standfield of the Ontario Department of Lands and Forest, and Dr. A. Wilkes of the Canadian Department of Agriculture, Science Service, Ottawa.

THE DISTRIBUTION MAP

Figure 1 shows the places at which the eight American members of the *affinis* subgroup have been collected. Specimens have mostly been individuals attracted to bait (usually fermenting banana) exposed in wooded areas. Identifications have ordinarily been based on males only, since females of these closely related species are usually difficult to distinguish. Two of the species, *dobzhanskii* and *seminole*, have each been reported from one locality only, as is designated on the map by the initial letters of these species names. On the other hand, fairly large geographical distributions are indicated for the remaining six species, as is discussed in the following paragraphs.

D. affinis is widely distributed in the eastern United States from the western Great Plains to the Atlantic coast. The species extends north as far as a line from central Minnesota to southern Quebec. Although collecting has been uneven over the eastern United States, there seems to be no reason to doubt that *affinis* is more or less continuously distributed throughout this area, especially since it has proven to be abundant in collections over most of this range (as is shown in the tables, below). Sturtevant and Dobzhansky (1936) described a *D. affinis* subspecies, *iroquois*, distinguished from typical *affinis* by somewhat darker pigmentation and reported from Massachusetts, New York, New Jersey, and Mississippi. Since this form has not been distinguished in most collections of this species, no attempt has been made to show its distribution here.

The distribution of *algonquin* broadly overlaps that of *affinis* but is distinct from it. The western boundary of the range of *algonquin* appears similar to that of *affinis*. However, *algonquin* has not been reported from the extreme southeastern part of the United States; its

southeastern boundary seems to lie near a line from southern Texas to New Jersey. The northern limits of distribution of *algonquin* would seem from the map to be similar to those of *affinis*. As is shown in Table I and further discussed below, however, *affinis* is rare in this region, while *algonquin* is often abundant. This is particularly true near the Great Lakes and the St. Lawrence River. This suggests that the actual northern boundary of the range of *algonquin* may lie well to the north of the northernmost points recorded on the map for this species.

D. athabasca has a much wider distribution than either of the other species just discussed and is, indeed, one of the most widely distributed native *Drosophila* species of North America. As is shown on the map, the range of *athabasca* extends from central Alaska to eastern Canada and to New England, southward along the Pacific coast to central Oregon, south in the Rockies to New Mexico, and

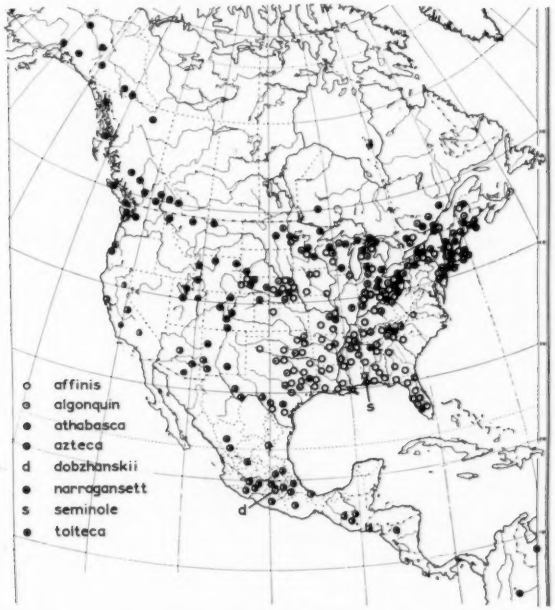


Fig. 1.—Map showing the collection localities of the eight American species of the *Drosophila affinis* subgroup. For the reason discussed in the text, *D. athabasca* is not shown at St. Louis or in Mississippi or Alabama, though the data of Tables I and III have been left unchanged as to the presence of the species in those places. (Goode's Series of Base Maps, No. 102; copyright 1937 by the University of Chicago.)

south in the Appalachians to the Great Smokies of Tennessee and North Carolina. *D. athabasca* must be much more widespread in Canada than the map shows it to be, since the species has been found to be very common at nearly all Canadian collecting localities, and these places, though widely scattered, are restricted to only a small part of that country.

Some features of the distribution of *athabasca* are doubtful. For example, the southward extent of this species along the Atlantic coast is uncertain, due to a lack of collecting records south of New York and New Jersey, where the species has been reported to be common (see Tables III and V). The question of whether *athabasca* occurs in the central and southern Middle West involves an uncertainty of another kind, a possible misidentification of *affinis* as *athabasca* in some of the collections. Males of *athabasca* are distinguishable from *affinis* and *algonquin* males by the sex combs (as illustrated in Sturtevant and Dobzhansky, 1936). The large size of the *algonquin* sex combs and their orientation nearly parallel to the axis of the first tarsal segment make males of this species especially easy to distinguish from males of the other two, both of which have small sex combs oriented at a greater angle with respect to the tarsal segment axis. On the other hand, the identification of males as either *affinis* or *athabasca* appears to have caused some difficulty in places where *affinis* presumably exists without *athabasca* or with very few of the latter species. The presence of *athabasca* in Nebraska was shown to be doubtful by Miller (1955), who proposed a sex comb index for separating males of *affinis* and *athabasca* according to the length of the sex comb relative to the length of the first tarsal segment. On this basis the conclusion of Williams and Miller (1952) that *athabasca* existed in this state is suspected of being incorrect, so the map does not show this species in Nebraska. A similar difficulty of identification may have been experienced by Carson and Stalker (1951), who reported *athabasca* as well as *affinis* at St. Louis, Missouri. These workers have kindly made available to this author both pinned and living specimens from the St. Louis area, and so far none of these has been determined to be *athabasca*, though *affinis* and *algonquin* were clearly present in their collections. On this account, *athabasca* has not been shown on the map as occurring in Missouri, and similarly it has been omitted from certain points southeast of St. Louis (Mississippi and Alabama localities, Table I) where it was recorded as present in the unpublished collection data of Dr. H. D. Stalker, although the Table I and Table III data furnished by Drs. Carson and Stalker have been left unaltered as to the presence of this species at St. Louis and the Mississippi and Alabama localities. Reports of *athabasca* in the Great Smokies of Tennessee and North Carolina are undoubtedly correct, since laboratory cultures of this species from that area have been successfully used in breeding experiments with members of the species from elsewhere (e.g., by Novitski, 1946). As a consequence of omitting *athabasca* from the lower Middle West the distribution of this species

shown on the map differs from that given in the paper of Buzzatti-Traverso and Scossiroli (1955), who showed *athabasca* to extend southward to a boundary lying across the southern plains from New Mexico to eastern Tennessee.

The original description of *athabasca* included the recognition of an eastern subspecies, *mahican* Sturtevant and Dobzhansky, 1936, characterized by paler pigmentation than that of typical *athabasca*, and reported from New Hampshire, Massachusetts, and New Jersey. Novitski (1946) concluded that laboratory stocks of *mahican* were not distinctly different from other stocks of *athabasca* in this respect and, consequently, disregarded the subspecific designation in his consideration of the species. The present author has observed that some *athabasca* collected at Cold Spring Harbor, New York, were definitely lighter than members of the species from elsewhere, including other eastern localities (Michigan, Ontario, and Quebec). However, since most collection records for this species do not include reference to the pigmentation characteristics on which recognition of *mahican* is based, it has seemed best to ignore the subspecific designation in this paper also. It should be interesting to investigate further the variation of pigmentation in eastern *athabasca*. Other evidence of intraspecific variation in *athabasca* has come from studies of sexual isolation between different geographical strains (Miller, 1958); stocks from Michigan have shown a high degree of isolation with respect to cultures from Wyoming and New York, which showed less isolation with respect to each other, but hybrids produced from successful interlocality crosses were fertile.

Figure 1 shows that *azteca* has a geographical distribution extending from northern California to Guatemala. This range appears discontinuous in places, perhaps partly due to a scarcity of collections, but probably in part due to an actual interruption of the distribution of this forest-dwelling species by the deserts of northern Mexico and the southwestern United States. *D. azteca* slightly overlaps the distributions of *affinis* and *algonquin* in southern Texas. However, it has not so far been shown to overlap the range of *athabasca* in the southern Rockies. In southern Mexico *azteca* overlaps the ranges of *dobzhanskii* and *tolteca*. Regarding the latter species, Dr. M. R. Wheeler informs the writer that *tolteca* is generally collected at lower elevations than *azteca*, suggesting some ecological isolation between these two species in their zone of overlap.

D. narragansett has a wide distribution in the eastern United States, with a range resembling very much that of *affinis*. However, unlike the other widespread *affinis* subgroup species of eastern North America, *narragansett* is very seldom common in collections in which it does occur (though in certain months it has been rather common at St. Louis, as is shown in the data of Carson and Stalker given in Table III). Consequently, data on the distribution of this species have been more difficult to evaluate than have been those of related species, and the sudden appearance of *narragansett* in certain remote collec-

tions has been rather surprising. For example, *narragansett* was not reported in Nebraska by Williams and Miller (1952), but it has since turned up in this state as a few individuals at Lincoln in the collections of Dr. Weeks (Table III) and at Chadron State Park in the collections of Miller, Sulerud, and Williamson (Table I). Dr. H. D. Stalker sent the author several specimens of this species collected at St. Petersburg, Florida, in December, 1952. Since the remoteness of that locality from previous collecting points made it seem that the specimens might not actually be *narragansett* (for example, might possibly belong to *seminole*, which *narragansett* would seem to resemble, according to Sturtevant and Dobzhansky, 1936), an attempt was made to cross females of the derived St. Petersburg strain to males of a *narragansett* stock from Amherst, Massachusetts, which had been provided by Dr. P. T. Ives of Amherst College. Since this cross yielded fertile progeny, it was concluded that the St. Petersburg form represented true *narragansett*.

D. tolteca is distributed from Mexico to the South American countries of Colombia and Venezuela. South American strains provided by Dr. M. R. Wheeler were tested by reciprocal crosses to the Nicaraguan strain by Mr. Stewart Ensign, who found that these crosses all gave fully fertile offspring and, hence, concluded that the Colombian and Venezuelan strains represented *tolteca*. The apparent discontinuous nature of the distribution of *tolteca* may well be due to a scarcity of collections in Central America.

The existence of the *affinis* subgroup elsewhere in South America remains doubtful. Duda (1927) reported *D. affinis* from Paraguay. Although it was suggested by Sturtevant and Dobzhansky (1936) that this report might involve an error of locality identification, our present knowledge of the existence of *tolteca* in northern South America makes it seem more likely that a member of the *affinis* subgroup does occur as far south as Paraguay[1].

RELATIVE FREQUENCIES OF "AFFINIS" SUBGROUP SPECIES IN EASTERN NORTH AMERICA

The four species *affinis*, *algonquin*, *athabasca*, and *narragansett* have been collected together in many places in eastern North America. Data on the relative frequencies of these species in collections should be useful for drawing conclusions concerning the centers and boundaries of their distribution areas, and for understanding their ecological relations as revealed by seasonal variation in relative frequencies and variation from place to place within the same area. Tables I - V present relative frequencies of these four species (among themselves) at various collecting localities in the eastern United States and Canada. In the majority of cases the species frequencies

[1] Recently Dr. M. R. Wheeler of the University of Texas has provided the author with a culture of what seems to be *D. tolteca* from Coroicó, Bolivia (collection of M. Wasserman).

TABLE I.—Frequencies and sex ratios of *D. affinis, algonquin, athabasca,* and *narragansett* in collections in eastern North America. Data from localities at which collections were made during no more than one month of the year or for which collecting data for more than one month were pooled.

Place and Date (Collector)	No. of flies	Species ratio of males: *aff.* *alg.-ath.-narrag.* (percent)	Sex ratio
NORTH OF 45° N. LATITUDE (WEST TO EAST)			
Halstad, Minn. (Sulerud) Summer, 1957	274	26-66-8-0	1:3.1
Little Falls, Minn. (Stalker) August, 1956	110	9-84-7-0	1:1.6
Iron River, Wis. (Stalker) August, 1956	120	1-53-34-0	1:2.8
Iron Mountain, Mich. (Stalker) August, 1956	216	0-17-83-0	1:2.1
Petoskey, Mich. (Stalker) August, 1956	212	3-33-64-0	1:2.3
Univ. Mich Biol. Sta. (Miller) July, 1954	1194	2-74-24-<1	1:0.9
Algonquin Pk., Ont. (Miller) August, 1956	274	1-16-83-0	1:0.8
Gatineau Pk., Que. (Miller) August, 1956	203	0-13-87-0	1:1.4
Ste. Anne de Bellevue, Que. August, 1956 (Miller)	144	1-62-38-0	1:2.2
Laurentides Pk., Que. (Miller) August, 1956	216	0-0-100-0	1:0.5
BETWEEN LATITUDES 40° AND 45° N. (WEST TO EAST)			
Chadron State Pk., Nebraska June, 1957 (Miller, Sulerud, Williamson)	252	98-2-0-<1	1:2.2
Keokuk, Iowa (Stalker) June, 1956	107	98-2-0-0	1:0.8
Crawfordsville, Ind. (Stalker) June, 1956	68	96-4-0-0	1:0.7
Plainwell, Mich. (Stalker) August, 1956	88	79-13-8-0	1:2.4
Windham, Vt. (Spiess, 1949) June-August, 1946	99	(19-4-76-0)	
Braintree & Cambridge, Mass. July-Sept., 1946 (Spiess, 1949)	150	(10-40-50-0)	
Penobscot Bay, Me. (Spiess, 1949) June, 1946	50	(0-8-92-0)	
BETWEEN LATITUDES 35° AND 40° N.			
Hopkinsville, Ky. (Stalker) June, 1956	149	100-0-0-0	1:0.7

TABLE I—(*continued*)

Place and Date (Collector)	No. of flies	Species ratio of males: *aff. alg.-ath.-narrag.* (percent)	Sex ratio
SOUTH OF LATITUDE 35° N. (WEST TO EAST)			
Austin, Texas (Wheeler)			
March, 1946	370	97-3-0-0	1:0.6
February, 1953	184	95-5-0-0	1:2.3
Collections of April, 1946 (Stalker)			
Mississippi			
Corinth	132	86-4-7-3	1:2.6
Alabama			
Hartselle	86	92-0-1-7	1:6.2
Lacon	23	91-0-9-0	1:22.0
Twin Oaks	62	95-0-5-0	1:14.5
Oak Park	96	96-0-4-0	1:47.0
Verbena	29	97-0-3-0	1:28.0
Montgomery	38	97-0-3-0	1:37.0
Orion	26	100-0-0-0	1:12.0
Troy	86	100-0-0-0	1:5.6
Ozark	19	100-0-0-0	1:8.5
Abbeville	80	99-0-1-0	1:7.0
Georgia			
Elison	324	100-0-0-0	1:1.6
Leory	201	100-0-0-0	1:2.4
Albany	262	100-0-0-0	1:1.2
Mitchell Co.	38	100-0-0-0	1:6.6
Thomasville	53	100-0-0-0	1:2.1
Florida			
Monticello	215	100-0-0-0	1:1.7
Madison	30	100-0-0-0	1:4.0
Wellborn	31	100-0-0-0	1:5.2

are based on males only (except for the data of Spiess, 1949, in Table I). Sex ratios (the species pooled for both females and males) are also included in the tables. Although all the data have been handled in essentially the same way, it seemed desirable to segregate the records in the separate tables according to the nature and extent of the information afforded.

In the majority of cases, collections were performed in a locality for only a short while (usually less than a month) during a single year, or else collection data of longer periods were pooled, thus giving no indication of possible seasonal variation at the locality. Such data have been incorporated into Table I, where they are arranged geographically in categories based on latitude zones and listed from west to east within each category. It may be seen from this table that the

relative frequencies of the four species varied greatly from place to place.

D. affinis, though generally rare north of 45° N. latitude, was usually the most common of these species throughout the eastern United States, reaching 100 percent in the extreme southeastern part of its range. *D. algonquin* may be seen to have had its highest frequencies in the north, exceeding 50 percent at places in Minnesota, Wisconsin, Michigan, and Quebec. Moreover, its frequency was consistently high at Rochester, New York (Table III). *D. athabasca* was also most frequent in the north, exceeding 50 percent at points in Michigan, Ontario, Quebec (where it reached 100 percent in the Laurentides Park), and New England. It was also the most common species at Englewood Cliffs, New Jersey (Levitan, 1954; Table III), and at all elevations in the Great Smokies near Gatlinburg, Tennessee (Table IV). *D. narragansett* was rare or absent in these collections, though it reached 7 percent at Hartselle, Alabama.

Table I also shows variation of sex ratio in the pooled data for these species. Deviations from a 1:1 sex ratio have often been

TABLE II.—Frequencies and sex ratios of *D. affinis, algonquin, athabasca,* and *narragansett* in collections in Ohio. Unpublished data of Professor W. P. Spencer and associates. Data pooled for different places within each latitude range and for different years of collection (1936 to 1947).

Places	No. of flies	Species ratio of males: *aff.-alg.-ath.-narrag.* (percent)	Sex ratio
Latitudes 41°-42° N. Counties: Defiance, Ottawa, Cuyahoga, Williams, Ashtabula Mahoning.	980	49-44-6-0	1:1.8
Latitudes 40°-41° N. Counties: Mercer, Champaign, Marion, Crawford, Richland, Ashland, Licking, Wayne, Holmes, Muskingum, Stark.	20,122	77-15-8-<1	1:2.2
Latitudes 39°-40° N. Counties: Butler, Hocking, Athens.	3,955	91-6-3-<1	1:3.1
Latitudes 38°-39° N. Scioto County.	1,162	96-<1-4-<1	1:2.7

reported in *Drosophila* collections, for example, by Levitan (1954), whose Englewood Cliffs, New Jersey, collections included a large proportion of *affinis* subgroup specimens. Table I shows that greater or less inequalities of males and females generally existed in these *affinis* subgroup species, with the deviations sometimes in one direction and sometimes in the other but most often involving an excess of males. There is no clearly evident geographical pattern for these ratios, except for the fact that the most extreme deviations from a 1:1 ratio were reported in the various localities in Alabama, where collecting was done in April, 1946, by Dr. H. D. Stalker, who informs the author that a number of those collections were made during the middle of rather hot, dry days.

Table II summarizes the extensive collection data of Professor W. P. Spencer and associates in Ohio. These data were accumulated over the years 1936 to 1947 and during various months of those years (though mainly June, July and August) and in numerous places (though most often in the vicinity of Wooster). The data have been pooled in categories based on 1° latitude bands across the state. It may be seen that *affinis* was always the most abundant of the four *affinis* subgroup species, with *algonquin, athabasca,* and *narragansett* having lower frequencies in descending order. The frequencies of *affinis* and *algonquin* clearly varied inversely with respect to each other from north to south, *affinis* having a rising gradient of frequencies (49 percent to 96 percent) in that direction, *algonquin* a descending gradient (44 percent to less than 1 percent). These variations of frequency are consistent with the general impression given in Table I that *affinis* becomes more common as one proceeds southward; *algonquin* is more abundant in the north, especially near the Great Lakes.

Table III represents collections from places at which the data of the diffeernt months and/or seasons of one or more years were segregated. The frequencies of *affinis* and *algonquin* show clear seasonal variations at Lincoln and St. Louis. In the 1947 collections at Lincoln *affinis* started out with a relatively low frequency in the spring, rose to a maximum in the summer, and became less frequent in the fall, while *algonquin* had rather high frequencies in the spring and fall and a lower one in the summer (Williams and Miller, 1952). The 1952 data from Lincoln show the same sort of frequency relationship for these species, but the frequencies of *algonquin* in that year were much lower than in the corresponding months of 1947. The data of 1953 and 1955 at Lincoln show still different frequencies of these species in the month of May. It should be added, however, that the collections of the different years were made at different collecting sites, a fact which may have contributed to the year to year differences. The St. Louis data of Drs. Carson and Stalker (unpublished) are complicated by the possibility that *affinis* may sometimes (or often) have been mistakenly reported as *athabasca.* Nevertheless the frequencies of *algonquin* — the identification of which is not doubtful — and of specimens identified as *affinis* appear to have followed much the same

TABLE III.—Frequencies and sex ratios of *D. affinis, algonquin, athabasca,* and *narragansett*. Data from localities for which collections were recorded separately for different months of one or more years.

Place and Dates (Collector)	No. of flies	Species ratio of males: *aff. alg.-ath.-narrag.* (percent)	Sex ratio
Lincoln, Nebraska (Williams and Miller, 1952)			
1947 (Williams)			
May	243	43-57-0-0	1:4.8
June	107	77-23-0-0	1:1.3
July	2,266	79-21-0-0	1:1.5
August	1,562	72-28-0-0	1:1.5
September	404	31-29-0-0	1:1.8
October	116	30-70-0-0	1:1.5
1952 (Miller)			
May	147	85-15-0-0	1:0.8
June	105	96-4-0-0	1:0.8
July	171	99-1-0-0	1:0.8
August	50	100-0-0-0	1:1.2
September	149	97-3-0-0	1:1.6
1953 (Miller, Weeks)			
May	331	64-35-0-1	1:3.7
1955 (Miller)			
May	122	73-27-0-0	1:2.7
St. Louis, Missouri (Carson and Stalker, unpublished; males only)			
1946			
February	(188)	0-100-0-0	
March	(695)	1-95-1-5	
April	(203)	5-70-8-17	
May	(2,374)	8-38-53-1	
June	(796)	30-21-21-0	
July	(788)	16-2-81-0	
August	(1,667)	30-1-69-0	
September	(400)	37-7-56-0	
October-November	(270)	7-51-41-0	
December	(258)	3-25-72-0	
1947			
May	(574)	6-32-61-1	
June	(302)	12-27-62-0	
September	(406)	14-14-61-0	
October	(983)	11-7-82-0	
Rochester, New York (Miller)			
1941			
June	538	4-93-2-1	1:4.2
July	959	3-95-2-0	1:3.1
August	324	5-92-3-0	1:2.5
Englewood Cliffs, New Jersey (Levitan, 1954; *ath.* & *narrag.* together)			
1948			
May-June	1,435	13-8-79	1:3.9
August-October	1,960	12-4-84	1:3.0
1949			
March-April	531	1-13-87	1:2.1
May-June	1,452	1-6-93	1:2.0

sort of pattern of seasonal variation reported for these species at Lincoln. The Rochester, New York, data for June through August of 1941 are remarkable in that they show uniformly very high frequencies of *algonquin*. The Englewood Cliffs data (Levitan, 1954) show that in each of the two years *algonquin* was more abundant in collections early in the season than it was later.

Table IV is a presentation of unpublished collecting data of Drs. Carson and Stalker at different elevations in the Great Smoky Mountains of Tennessee. Here *narragansett* was not reported and *algonquin* had uniformly low frequencies at the different altitudes. The identifications of *affinis* and *athabasca* may be considered more reliable than those of the St. Louis data of Table III, since *athabasca* is definitely known from the Great Smokies. It may be seen that *athabasca* was reported as the most common of these species at all elevations and from a minimum frequency at 1400 ft. it was shown to have a rising gradient of frequencies with increasing altitude, reaching a 99 percent maximum at the highest elevation, 6,000 ft. Conversely, the frequencies of *affinis* decreased with increasing altitude from 1400 to 6000 ft.

Table V is based on data from collections of the author at Cold Spring Harbor, New York, during three weeks from mid-August to early September, 1955. These data have been segregated from the rest because the collection effort was divided more or less equally between two rather different sites, and between mornings and evenings, and these different sites and collecting times gave certain differences (in some cases significant) of species frequencies (*affinis* and *athabasca*) and sex ratio. Site A was a rather wet (springs and almost marshy surroundings) situation just north of the Long Island Biological Association laboratories. Site B was a relatively dry, sloping, well-drained location near the buildings of the Carnegie Institution of Washington and the Long Island Biological Association, approximate-

TABLE IV.—Frequencies and sex ratios of *D. affinis, algonquin,* and *athabasca* collected at different elevations in the Great Smoky Mountains near Gatlinburg, Tennessee, in July, 1947. Unpublished data of Drs. H. L. Carson and H. D. Stalker.

Elevation (feet)	No. of flies	Species ratio of males: *affinis-algonquin-athabasca* (percent)	Sex ratio
1,000	120	16-1-83	1:2.8
1,200	258	30-1-69	1:4.4
1,400	468	41-1-59	1:2.8
2,000	1,137	22-1-78	1:2.3
3,000	1,089	15-1-84	1:2.4
4,000	1,330	12-1-88	1:2.4
5,000	276	5-0-95	1:2.6
6,000	201	1-0-99	1:2.1

ly 1000 ft. south of Site A. Table V shows that *affinis* was invariably less common at Site A than at Site B and, conversely, *athabasca* always more common at Site A than Site B. Moreover, application of the Chi-square test showed the frequencies of these two species were significantly different at the two localities not only for the totals of morning and evening collections for the entire period but also for the separate weeks of the collecting period. In addition, the frequencies of *affinis* and *athabasca* differed in the morning and evening collections, especially at Site A, where *affinis* was always more common in the evening than in the morning, *athabasca* more common in the morning than in the evening, with the difference in relative frequencies of these species between mornings and evenings being highly significant in the entire collection totals and in the totals for the first week (though not in those of the second and third weeks). It may also be seen from Table V that the sex ratio varied from place to place and time to time. Some of the sex ratio differences were calculated to be significant. A highly significant sex ratio difference between the two localities was found in the morning collections of the first week, and the morning collections of the second and third week showed significant differences between sex ratios at the two sites, but the differences were in the opposite direction from that of the first week! At Site A in the third week there was a highly significant difference between morning and evening sex ratios.

DISCUSSION OF THE INCIDENCE AND DISTRIBUTION OF "AFFINIS," "ALGONQUIN," AND "ATHABASCA" IN EASTERN NORTH AMERICA

The geographical range of a *Drosophila* species may well be considered to be a dynamic entity, as was emphasized, for example, by Carson 1955), who stressed the dynamic nature of intracontinental boundaries of a species range. Within the region covered by such a species there must be much variation in population density, depending on variation of the environment from place to place within this area. Moreover, with changes of the environment (seasonal, year to year), the *Drosophila* populations should change rather rapidly, since these insects have short life cycles and the adults presumably do not live very long. The distribution boundaries of such a species should likewise fluctuate, except inasmuch as they are fixed by natural barriers, such as an ocean. With changing environmental conditions a species may sometimes extend itself into previously unoccupied territory, sometimes withdraw from a region, possibly leaving isolated subpopulations behind.

There are many difficulties in the way of getting a very accurate picture of the geographical distribution of a *Drosophila* species. For one thing, the data on which such a picture is based must necessarily come from numerous sources, representing the collections of various investigators at different times and places. The records may be complicated by difficulties of species identification. Since collections

TABLE V.—Frequencies and sex ratios of *D. affinis, algonquin,* and *athabasca* in collections at Cold Spring Harbor, New York, 1955. Data separated according to week, collecting area, and time of day. Descriptions of collecting areas given in text.

Week Collecting Area Time of Day	No. of flies	Species ratio of males: *aff.-alg.-ath.* (percent)	Sex ratio
First week (13-19 August 1955)			
Site A			
Morning collections	245	38-1-61	1:1.1
Evening collections	292	58-1-41	1:1.5
Site B			
Morning collections	96	66-1-33	1:3.6
Evening collections	96	75-0-25	1:1.9
Second week (20-26 August 1955)			
Site A			
Morning collections	257	39-1-60	1:2.1
Evening collections	196	45-3-52	1:1.7
Site B			
Morning collections	28	73-0-27	1:1.2
Evening collections	34	88-0-12	1:2.4
Third week (27 August - 2 September 1955)			
Site A			
Morning collections	145	48-5-47	1:3.7
Evening collections	298	54-4-42	1:1.7
Site B			
Morning collections	111	72-7-21	1:2.2
Evening collections	211	73-<1-27	1:1.9
Entire Collecting Period (13 August - 2 September 1955)			
Site A			
Morning collections	647	41-2-57	1:1.8
Evening collections	786	53-3-44	1:1.6
Site B			
Morning collections	235	69-4-27	1:2.4
Evening collections	341	75-<1-25	1:2.0

will have been made in different years and different seasons, the combined data can hardly be considered to afford anything like a synoptic picture of a species distribution. Moreover, only rarely will collections at the same locality be sufficiently prolonged to give an idea of seasonal or year to year changes. The difficulty due to seasonal variation may, however, be somewhat counterbalanced by the fact that, especially in northern latitudes, most collecting will have been concen-

trated in summer months, when it might be expected that the *Drosophila* populations are at a maximum.

The already mentioned seasonal variation of relative frequencies of *affinis* and *algonquin* at Lincoln and St. Louis (Table III may well represent a general relationship of these species at places where they coexist, though the actual freqeuncies may vary considerably from place to place and year to year (as is also indicated in the table). In the cooler parts of the year, *algonquin* is relatively abundant, sometimes even more common in collections than *affinis,* though in most of the collections at Lincoln and St. Louis *affinis* (or *affinis* plus *athabasca* at St. Louis?) was the more common species. This relationship seems consistent with the fact that *algonquin* is generally a more northern species than *affinis,* with much higher frequencies than *affinis* at the northernmost places where they are found together. On the other hand, one might wonder whether *algonquin* could be collected in those southern localities where it has not been found if collecting were conducted during the coolest part of the year, at least in years of unusually cool weather.

As mentioned earlier, most of the collecting on which this report is based was done by exposing bait, usually fermenting banana, and collecting from the flies attracted to the bait. This introduces another variable: presence and absence of species and variation of relative frequencies of the species (and of the sexes) in collections may well have been influenced not only by the numbers of the different kinds in the population but also by differential mobility of the different kinds of flies to the bait. In addition to this factor of differential mobility there are possibly environmental factors which influence the collecting. These include temperature, illumination, humidity, wind, and the nature and condition of the bait. It has not generally been the practice to secure data on such environmental factors at the times of collection.

The collections at Cold Spring Harbor (Table V) give some insight into the possible influence of environmental factors on the collection of the *affinis* subgroup species. Unfortunately, these collections, which were made to obtain *athabasca* for experimental work, were not accompanied by the taking of records on ecological conditions, so only a general idea of the circumstances attending the collections can now be had. As already mentioned, Site A had more moisture than Site B. It is also true that mornings generally gave the impression of a higher humidity than evenings, judging from the heavy dew often encountered on the vegetation in the mornings but not in the evenings. As was already pointed out, Table V shows that *athabasca* was invariably more common at Site A than at Site B and, moreover, that at Site A *athabasca* was always more common in the mornings than in the evenings. The difference between the species frequencies at the two collecting sites could, of course, have been due to a more abundant breeding of *athabasca* at Site A than at Site B (and conversely for *affinis*). The evidence of morning-evening differ-

ences in the frequencies of the two species at Site A would seem to mean that the diurnal variation of environmental conditions, perhaps largely a change of humidity, influenced differentially the mobility of the two species to the bait, the movement of *athabasca* being favored by a high relative humidity. Hence the over-all higher frequency of *athabasca* at Site A may have been due to a greater mobility of *athabasca* at Site A. Information on the actual breeding sites of these two species at Cold Spring Harbor or similar places would be most interesting. Inasmuch as variation in sex ratio in the different collections at Cold Spring Harbor may be taken as significant, it likewise suggests a differential influence of the environment on the mobility of the two sexes to the bait.

Although the *affinis* subgroup species *affinis, algonquin,* and *athabasca* are together the most abundant native *Drosophila* species of eastern North America, very little is known about their ecological relations, in particular, their breeding sites. These species are, however, regularly found in forests, and there is some evidence of their association with trees and other plants of the forests. Sturtevant (1921) writes that *affinis* is not rare about bleeding trees, and in Sturtevant and Dobzhansky (1936) it is stated that Sturtevant collected members of the *affinis* subgroup by sweeping a net over tree trunks and obtaining specimens on bleeding trees. Carson and Stalker (1951) reported that at St. Louis *affinis* was found breeding in small fruits, and *athabasca* (though possibly *affinis?*) in fleshy fungi, slime fluxes of red oak, and in small fruits, though the frequencies with which these breeding sites were encountered were so low that it seemed that these very common species must have had other more important natural breeding sites. Wheeler (as reported in Patterson and Stone, 1952) reported *affinis* breeding in the sap of a bleeding wild grapevine in Texas. In the summer of 1956 the present author bred a single *D. algonquin* female out of a fleshy fungus collected in Algonquin Park, Ontario.

In spite of uncertainties as to the faithfulness with which the available data reveal the geographical distributions of *affinis, algonquin,* and *athabasca,* some tentative conclusions on these distributions may be drawn, with speculations on some details of the distributions and the probable factors responsible for the distributions.

Judging from its high relative frequencies (with respect to *algonquin*) during the summer at Lincoln and St. Louis (Table III), *D. affinis* seems to be primarily a species of the southeastern United States, generally favored by high temperatures and/or other summer conditions. The western limit of its range appears to lie close to the western boundary of the Great Plains and may well be very irregular, following the vegetation along river bottoms, as is reported for *D. robusta* by Carson (1955), though, unlike *robusta,* no such natural breeding site as the American elm (which harbors *robusta*) is known. Collection records are too meager to serve as a basis for describing the western boundary of this species. With respect to other members of

the *affinis* subgroup, *affinis* is relatively very frequent even in the westernmost part of its range (Chadron State Park, Nebraska, Table I). However, with respect to the more distantly related *D. pseudoobscura* (*obscura* subgroup of the *obscura* group), *affinis* diminishes in frequency westward across Nebraska while *pseudoobscura* increases (a similar relationship exists in Texas; Patterson and Wagner, 1943). As mentioned earlier, *affinis* diminishes in the north so as to be rare relative to *algonquin* and/or *athabasca* in a zone extending from Minnesota to Quebec and New England. The high relative frequency of *affinis* at Halstad, Minnesota, with respect to other places north of 45° N. latitude (Table I) and the somewhat low frequencies of *affinis* in New England with respect to places farther west between 40° and 45° suggest that the northern boundary of this species is oriented in a northwest-southeast direction rather than east and west (though the species has not yet been reported from North Dakota, perhaps because of a scarcity of collections).

D. algonquin appears to be a northern species with its greatest abundance in the Great Lakes and St. Lawrence region. In general its frequencies diminish to the west, south, and east of this area (Tables I and II), but even remote from this region (Lincoln and St. Louis) it reached high frequencies in the cooler months of the year (Table III). As already mentioned, the western boundary of *algonquin* appears similar to that of *affinis*. In the east (Quebec, New England) it decreases with respect to *athabasca*. This may be true in the north as well, but a lack of collections in Canada north of the Great Lakes makes it impossible to show this. In other directions it decreases with respect to *affinis*. Low frequencies of this species in such southeastern and southern points as Gatlinburg, Tennessee (Table IV), and Austin, Texas (Table I), suggest that the species approaches the margin of its distribution near those places, as does the absence of reports of this species in the extreme southeast (Table I). Though it remains to be investigated, there would seem to be a reasonable possibility that the southeastward extent of this species is limited by the southeastern boundary of the hardwood forests and that the species is excluded from the southeastern evergreen forests of the Atlantic and Gulf coasts (judging from the limits of these forest regions shown in Braun, 1950).

D. athabasca is an inhabitant of the boreal forests of Alaska and Canada, but it extends southward well out of this region. In eastern North America this was the only species of the subgroup collected in the boreal forest of the Laurentides Park, Quebec (Table I), but in the mixed or hardwood forests where it was otherwise collected in the east it was invariably obtained along with other species of its subgroup. Its probable absence in most of the Great Plains and in the lower Middle West has already been mentioned. In the eastern United States and adjacent Canada its highest relative frequencies have been in the northern Great Lakes region, lower Ontario and Quebec, New England, and at high elevations in the Great Smokies, suggesting a preference for cool, damp situations, such as is also sug-

gested by its high frequencies at Site A at Cold Spring Harbor and in the morning collections at that location (Table V).

It would be desirable to have more collection records in which the *affinis* subgroup species were distinguished, both at new localities and at different times of the year. Eventually it may be hoped that important natural breeding sites of these species will be discovered. Knowledge of these should help in the evaluation of the variations in abundance of these species from place to place and from time to time.

REFERENCES

BRAUN, E. L. 1950—Deciduous Forests of Eastern North America. Blakiston, Philadelphia. 596 pp.

BURLA, H. 1948—Die Gattung Drosophila in der Schweiz. Rev. Suisse Zool. 55:272-279.

BUZZATTI-TRAVERSO, A. A. AND R. E. SCOSSIROLI 1955—The "Obscura Group" of the Genus *Drosophila*. Advances in Genetics 7:47-92.

CARSON, H. L. 1955—The genetic characteristics of marginal populations of *Drosophila*. Cold Spring Harbor Symp. Quant. Biol. 20:276-287.

——— AND H. D. STALKER 1951—Natural breeding sites for some wild species of *Drosophila* in the eastern United States. Ecology 32:317-330.

DOBZHANSKY, TH. AND C. EPLING 1944—Contributions to the genetics, taxonomy, and ecology of *Drosophila pseudoobscura* and its relatives. Carnegie Inst. Washington, Publ. 554:1-183.

——— AND D. SOKOLOF 1939—Structure and variation of the chromosomes in *Drosophila azteca*. Jour. Heredity 30:3-19.

DUDA, O. 1927(1925)—Die Südamerikanischen Drosophiliden unter Berücksichtigung auch der anderen neotropischen sowie der nearktischen Arten. Arch. Naturgesch. 91A, 11:1-229.

LEVITAN, M. 1954—Drosophilidae in New York and New Jersey. Amer. Midl. Nat. 52:453-459.

MILLER, D. D. 1939—Structure and variation of the chromosomes in *Drosophila algonquin*. Genetics 24:699-708.

———1941—Interspecific hybrids involving *Drosophila athabasca*. Genetics 26:161 (abstract).

———1955—A study of sex combs in *Drosophila affinis* and *athabasca*. Trans. Amer. Microsc. Soc. 74:191-197.

———1958—Sexual isolation and variation in mating behavior within *Drosophila athabasca*. Evolution 12:72-81.

NOVITSKI, E. 1946—Chromosome variation in *Drosophila athabasca*. Genetics 31:508-524.

PATTERSON, J. T. 1943—The Drosophilidae of the Southwest. Univ. Texas, Publ. 4313:7-216.

———1954—Note on a new case of interspecific hybridization in the *affinis* subgroup. Univ. Texas, Publ. 5422:46.

——— AND G. B. MAINLAND 1944—The Drosophilidae of Mexico. Univ. Texas, Publ. 4445:9-101.

——— AND W. S. STONE 1952—Evolution in the Genus *Drosophila*. The Macmillan Company, New York. 610 pp.

——— AND R. P. WAGNER 1943—Geographical distribution of species of the genus *Drosophila* in the United States and Mexico. Univ. Texas, Publ. 4313:217-281.

SPIESS, E. B. 1949—*Drosophila* in New England. Jour. New York Ent. Soc. 57:117-131.

STURTEVANT, A. H. 1916—Notes on North American Drosophilidae with descriptions of twenty-three new species. Ann., Ent. Soc. America 9:323-343.

———1921—The North American Species of *Drosophila*. Carnegie Inst. Washington, Publ. 301-1-150.

——— AND TH. DOBZHANSKY 1936—Observations on species related to *Drosophila affinis*, with Descriptions of Seven New Forms. Amer. Nat. 70:574-584.

WILLIAMS, D. D. AND D. D. MILLER 1952—A Report on *Drosophila* Collections in Nebraska. Bull. Univ. Nebraska State Mus. 3:1-19.

The Chromatophore System of the Crawfish Orconectes clypeatus[1]

MILTON FINGERMAN
Newcomb College, Tulane University, New Orleans, Louisiana

In spite of the fact that much information is available concerning crustacean pigmentary systems, data on crawfish chromatophores are scanty. The pigmentary systems of only two species of crawfishes have been investigated in detail and both systems proved markedly different from one another.

Brown and Meglitsch (1940) found that the red pigment of the crawfish *Orconectes immunis* on a white background concentrated maximally and the white pigment dispersed maximally. The pigmentary states were reversed when the crawfish was placed on a black background. The sinus gland in the eyestalk of *Orconectes immunis* produced two chromatophorotropins, white pigment dispersing and red pigment concentrating. McVay (1942), also working with *Orconectes immunis,* demonstrated that the central nervous organs were potent sources of red and white pigment concentrating hormones.

Background responses of the dwarf crawfish, *Cambarellus shufeldti,* were the same as those of *Orconectes immunis* (Fingerman, 1957a). However, the endocrine control of the chromatophores of *Cambarellus* was different from that of *Orconectes immunis.* The eyestalks of *Cambarellus* produced appreciable quantities of white pigment dispersing and concentrating hormones and a red pigment dispering factor. The presence of a red pigment concentrating hormone in the eyestalk was also indicated by the results. The central nervous system was a source of significant quantities of four principles, red and white pigment dispersing and concentrating hormones.

The behavior of red and white chromatophores on isolated portions of the carapace of *Cambarellus shufeldti* was investigated by Fingerman (1957b) to determine the "resting states" of the chromatophores. The red pigment had an inherent tendency to concentrate nearly maximally and the white pigment to disperse nearly maximally when the red and white chromatophores were no longer under the influence of blood-borne factors. Responses of isolated chromatophores of *Cambarellus* to extracts of eyestalk and central nervous organs were complicated by the inherent tendencies of the white pigment to disperse and the red pigment to concentrate and were not the same as responses to extracts injected directly into the body cavity of *Cambarellus.*

Experiments that involved reciprocal blood transfusions between *Cambarellus* adapted to black and to white backgrounds have shown

[1] This investigation was supported by Grant No. B-838 from the National Institutes of Health.

that the blood always contained pigment dispersing and concentrating hormones. The degree of pigment dispersion at any time appeared to be determined by the relative quantity of each hormone in the blood (Fingerman, 1957b). The results obtained with *Cambarellus* differed from those of Koller (1925, 1927) who found that blood of the shrimp *Crago vulgaris* on a black background darkened a pale shrimp but that blood from a pale shrimp neither lightened a dark shrimp nor darkened a pale one. Evidently, the color of *Crago* on black and on white backgrounds depended upon the presence or absence of a pigment dispersing hormone alone.

In view of the differences between the chromatophore systems of the crawfishes *Orconectes immunis* and *Cambarellus shufeldti* an appraisal of the chromatophore system of another crawfish seemed worthwhile. Preliminary observations revealed that *Orconectes clypeatus* would be ideal for this investigation.

MATERIALS AND METHODS

Immature specimens of the crawfish *Orconectes clypeatus,* collected at Hickory, Louisiana, were used in the experiments described below. Specimens were about one inch in over-all length and had an exoskeleton thin enough in contrast to the opaque exoskeleton of adults to allow direct observation of the chromatophores. Crawfish were maintained in the laboratory in aquaria that contained aerated tap water one inch deep.

Red and white chromatophores in the portion of the carapace dorsal to the heart were staged according to the system of Hogben and Slome (1931) with the aid of a stereoscopic dissecting microscope and lamp. According to their scheme, stage 1 represented maximal pigment concentration, stage 5 maximal dispersion and stages 2, 3, and 4 the intermediate conditions.

Tissue extracts were prepared in the following manner. The organs to be assayed were dissected out and placed in van Harreveld's solution. When the desired number of organs was available, they were transferred with a minimum of saline to a glass mortar, triturated and resuspended in a sufficient volume of van Harreveld's solution to yield the desired concentration.

Orconectes that received injections of extracts had had one of their eyestalks removed at least 24 hours prior to the experiment. Brown, Webb, and Sandeen (1952) and Fingerman (1957a) found that responses to chromatophorotropins of one-eyed specimens were greater than responses of intact specimens, probably because the presence of both eyestalks makes the crawfish more capable of antagonizing injected hormones.

Two types of red chromatophores, light red and deep red, were present in the carapace. The former were generally smaller and more dispersed than the latter. The two types were not staged separately because they showed no qualitatively different response to tissue ex-

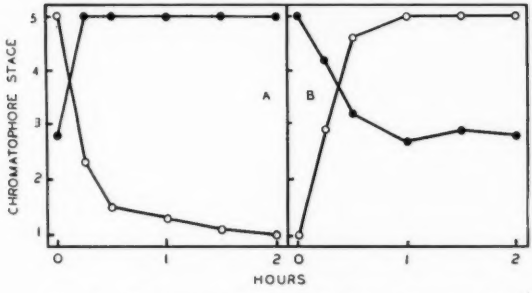


Fig. 1.—Responses of red and white chromatophores of *Orconectes clypeatus* to background changes. A, from white to black; B, from black to white. Circles, white chromatophores; dots, red chromatophores.

tracts. Instead, the average stage of all red chromatophores was determined. Brown and Meglitsch (1940) followed the same procedure with *Orconectes immunis*.

EXPERIMENTS AND RESULTS

BACKGROUND RESPONSES OF ORCONECTES CLYPEATUS

Crawfish were collected and returned to the laboratory where 20 were placed into a white enameled pan and 20 into a black enameled pan. Both pans, containing aerated tap water one inch deep, were placed under an illumination of 20 ft. c. light intensity for the duration of the experiment. After an adaptation period of 4.5 hours the average chromatophore stage of the 20 specimens in each pan was determined. The backgrounds were then interchanged with the result that the *Orconectes* that had been on a white background were on a black background and vice versa. The average chromatophore stage of the specimens in each pan was then determined 15, 30, 60, 90, and 120 minutes after the backgrounds had been interchanged.

The results have been used in the preparation of Fig. 1. The left half of the figure (A) represents the response of the crawfish that were originally on a white background and in part B are the responses of the crawfish that were originally on a black background. The white pigment behaved as anticipated, maximally dispersed on a white background and maximally concentrated on a black background, and migrated at about the same rate as the white pigment of *Cambarellus* (Fingerman, 1956a).

The red pigment of *Orconectes clypeatus* however, did not respond as anticipated. On a black background the red pigment was maximally dispersed (Fig. 1B), but on a white background the red pigment did not concentrate maximally. Instead the pigment attained

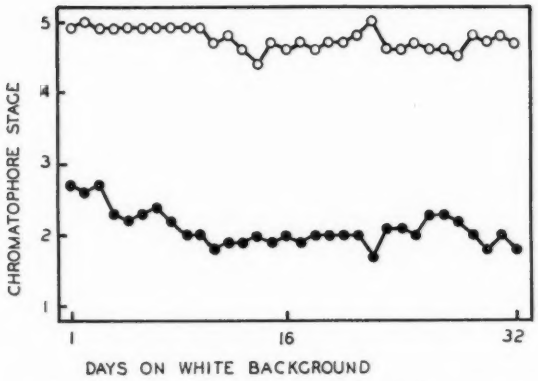


Fig. 2.—Effect of time on background upon the degree of dispersion of the red and white pigments of *Orconectes*. Dots, red chromatophores; circles, white chromatophores.

an intermediate condition, about chromatophore stage 3 (Fig. 1A).

To determine whether the red pigment of *Orconectes* would concentrate maximally if individuals were maintained on a white background for a long period of time, specimens were freshly collected and 125 were placed into white enameled pans, 25 per pan. The pans were then placed under a constant illumination of 20 ft. c. light intensity. For 32 consecutive days the average chromatophore stage of 50 of these individuals was determined. As evident from Fig. 2 the red pigment became slightly more concentrated but there was no indication that the red pigment would concentrate maximally. A tendency of the white pigment to concentrate slightly was also evident. *Orconectes clypeatus* was unable under normal conditions to concentrate fully its red pigment.

CHROMATOPHOROTROPINS IN THE EYESTALKS AND CENTRAL NERVOUS ORGANS OF ORCONECTES CLYPEATUS

Both eyestalks and the entire central nervous system were removed from several *Orconectes*. The central nervous system was divided into four portions, supraesophageal ganglia, circumesophageal connectives, thoracic nerve cord, and abdominal nerve cord. The structures were extracted as described above and resuspended in sufficient van Harreveld's solution such that the final concentration was one-third of a pair of eyestalks or one-third of each central nervous structure per 0.02 ml of extract.

Five one-eyed *Orconectes* were placed into each of six white enameled and six black enameled pans containing aerated tap water.

These crawfish had been on their respective backgrounds for at least 60 minutes. The average chromatophore stage of the five crawfish in each pan was determined prior to injection of extract or saline to assure that the red and white chromatophores were in the proper state of background adaptation.

The crawfish in a black and a white pan were injected with 0.02 ml of one of the extracts. The crawfish in the remaining one black and one white pan were injected with 0.02 ml van Harreveld's solution as a control. The average red and white chromatophore stages for the specimens in each of the 12 pans were then determined 15, 30, 60, 90, and 120 minutes after injecting the crawfish. The experiment was repeated once.

The results are presented in Figs. 3 (red chromatophores) and 4 (white chromatophores) where each point represents the average of 10 specimens. As evident from inspection of Fig. 3, eyestalks and central nervous organs contained red pigment concentrating hormone. No red pigment dispersing factor was apparent. The same extracts caused greater red pigment concentration in specimens with maximally dispersed red pigment than in crawfish on a white background whose red pigment was in an intermediate state. Evidently, the initial state of the pigment partially determined the degree of response.

Concentration was the principal response of the white pigment (Fig. 4W). However, a white pigment dispersing effect, although not large, was apparent (Fig. 4B). The abdominal nerve cord was the most potent source of white pigment dispersing hormone. The rate of return to stage 5 of the originally maximally dispersed white pigment was greater than the rate of return of the originally maxi-

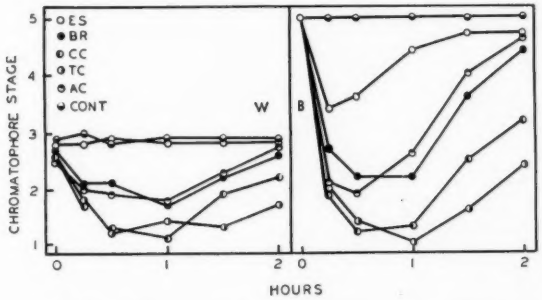


Fig. 3.—Responses of red chromatophores of one-eyed *Orconectes* on a white background (W) and on a black background (B) to extracts of eyestalks and central nervous organs. ES, eyestalks; BR, supraesophageal ganglia; CC, circumesophageal connectives; TC, thoracic nerve cord; AC, abdominal nerve cord; CONT, control, van Harreveld's solution.

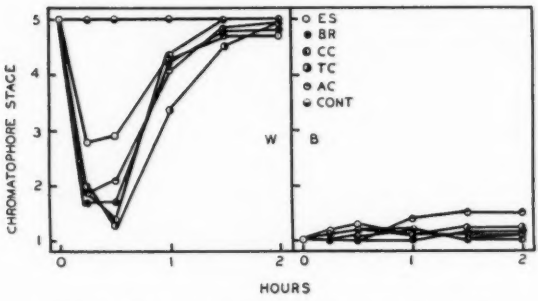


Fig. 4.—Responses of white chromatophores of one-eyed *Orconectes* on a white background (W) and on a black background (B) to extracts of eyestalks and central nervous organs. ES, eyestalk; BR, supraesophageal ganglia; CC, circumesophageal connectives; TC, thoracic nerve cord; AC, abdominal nerve cord; CONT, control, van Harreveld's solution.

mally dispersed red pigment. The difference was probably due to the action of the white pigment dispersing hormone.

BEHAVIOR OF ISOLATED CHROMATOPHORES

The dorsal portion of the carapace was removed from each of three crawfish that had been on a white background for at least one hour. The pieces of carapace were cut into 10 squares about 2 mm on a side and were placed into van Harreveld's solution on glass depression sides. The average stage of the red and white chromatophores on each piece of carapace was determined at the time of isolation and 15, 30, 60, 90, and 120 minutes thereafter. The experiment was then performed with crawfish from a black background and with crawfish both of whose eyestalks had been removed at least 24 hours prior to the experiment.

The three experiments were repeated and the results presented in Fig. 5 where each point represents the average of 20 squares from the carapace. Red pigment on carapace fragments from crawfish adapted to a white background did not change its degree of dispersion (Fig. 5A). White pigment of these specimens, however, concentrated to stage 3.7.

Maximally dispersed red pigment on carapace fragments removed from crawfish on a black background concentrated after isolation until the pigment was in an intermediate state. Maximally concentrated white pigment on the same fragments dispersed. After two hours of isolation the red and white pigments were nearly equally dispersed (Fig. 5B).

Maximally dispersed red and white pigments on carapace frag-

ments of eyestalkless crawfish concentrated after isolation, the red more than the white (Fig. 5C). Two hours after isolation the red pigment of the three groups of crawfish had attained approximately the same intermediate stage. The behavior of white pigment that had been maximally dispersed at the beginning of the experiment as a result of the white background was the same as that of white pigment maximally dispersed as a result of destalking (Fig. 5A, C). Presumably isolated white pigment of specimens from a black background would have ultimately reached the same stage as white pigment isolated from eyestalkless crawfish and crawfish on a white background.

RESPONSES OF ISOLATED CHROMATOPHORES TO CHROMATOPHOROTROPINS

This group of experiments was designed to determine the responses of isolated chromatophores to tissue extracts and to compare their behavior with the responses of red and white chromatophores of intact specimens to chromatophorotropins injected into the body cavity. The portion of the carapace dorsal to the heart was removed and split longitudinally into symmetrical halves. One portion was placed into 0.10 ml van Harreveld's solution to serve as a control and the second portion was placed into 0.10 ml tissue extract on a glass depression slide. The extracts consisted of one pair of eyestalks, the supraesophageal ganglia, or one abdominal nerve cord extracted in 0.10 ml van Harreveld's solution.

Responses of isolated chromatophores removed from crawfish on black and on white backgrounds to added chromatophorotropins were observed for two hours. The results are presented in Figs. 6, 7, and 8 where each point represents the average of 10 carapace portions. The

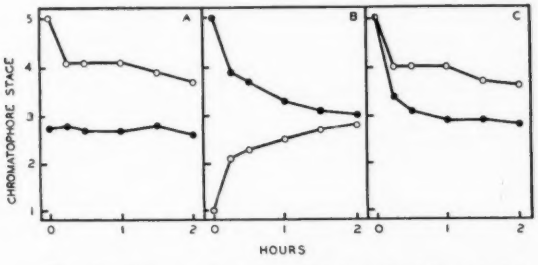


Fig. 5.—Responses of red (dots) and white (circles) chromatophores on isolated dorsal portions of crawfish carapace in van Harreveld's solution. A, removed from crawfish that had been on a white background; B, removed from crawfish that had been on a black background; C, removed from eyestalkless crawfish.

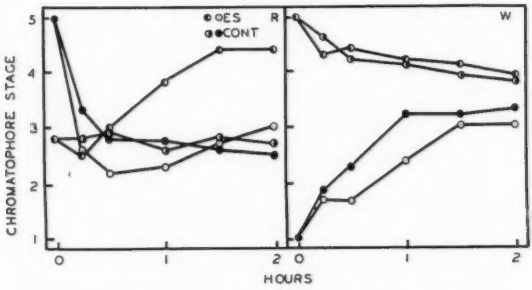


Fig. 6.—Responses of red (R) and white (W) chromatophores on isolated portions of crawfish carapace to eyestalk extract. ES, eyestalk; CONT, control, van Harreveld's solution.

left half of each figure represents the responses of red chromatophores, the right half white chromatophores.

The responses of isolated red chromatophores to eyestalk extract revealed red pigment dispersing and concentrating hormones (Fig. 6R). Concentration was evident from the dip of the eyestalk curve below the control curve and dispersion was subsequently shown by the rise of the eyestalk curve above the control curve. A white pigment concentrating hormone in the eyestalk extract was also evident. (Fig. 6W). However, if white pigment dispersing hormone were present, there was such a small quantity that its presence could not be definitely stated because the difference between the eyestalk curve and the control curve in the top half of Fig. 6W was as large as the difference found in staging the same set of chromatophores twice.

Responses of isolated red chromatophores to extracts of supraesophageal ganglia (Fig. 7R) revealed a red pigment dispersing factor was present in the extract. This hormone antagonized almost completely the red pigment concentrating hormone evident when extracts were injected into one-eyed individuals. Some red pigment concentration was observed on fragments removed from crawfish whose red pigment had been maximally dispersed because of a black background. Concentration was evident before the red pigment dispersing factor expressed itself.

White pigment dispersing and concentrating hormones were evident in the supraesophageal ganglia extracts (Fig. 7W). The originally maximally dispersed white pigment concentrated more rapidly than the controls due to the concentrating hormone and then redispersed almost to the original condition under the action of the dispersing principle. The originally maximally concentrated white pigment exposed to supraesophageal ganglia extract dispersed more rapidly than the controls.

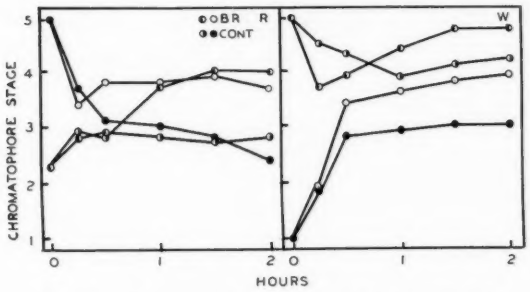


Fig. 7.—Responses of red (R) and white (W) chromatophores on isolated portions of crawfish carapace to supraesophageal ganglia extract. BR, supraesophageal ganglia; CONT, control, van Harreveld's solution.

Responses of red and white chromatophores on isolated portions of carapace to extracts of abdominal nerve cord revealed a red pigment concentrating hormone but no dispersing factor. However, a white pigment dispersing effect was evident (Fig. 8).

RESPONSES OF ORCONECTES TO TRANSFUSED BLOOD

Blood of *Orconectes* adapted to black and to white backgrounds was assayed upon one-eyed specimens likewise adapted to black and to white backgrounds. Van Harreveld's solution was used as a control. Each crawfish received 0.02 ml of either blood or saline. The blood was withdrawn from the region of the heart and injected as rapidly as possible to minimize clotting.

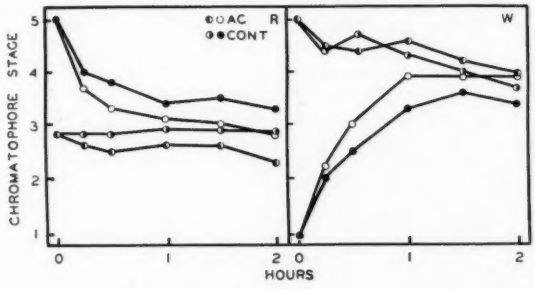


Fig. 8.—Responses of red (R) and white (W) chromatophores on isolated portions of crawfish carapace to abdominal nerve cord extract. AC, abdominal nerve cord; CONT, control, van Harreveld's solution.

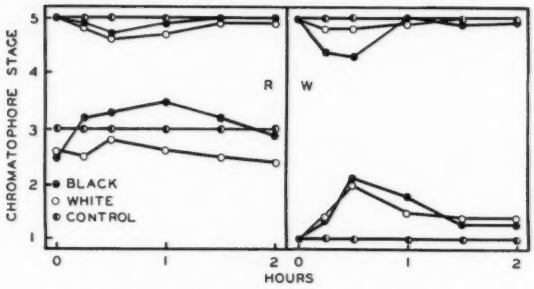


Fig. 9.—Responses of red (R) and white (W) chromatophores of crawfish on black and on white backgrounds to injection of (1) blood from crawfish on a black background (dots), (2) blood from crawfish on a white background (circles), and (3) van Harreveld's solution (half-filled circles).

The results are presented in Fig. 9 where each point represents the average of 10 individuals. Inspection of Fig. 9 revealed that the blood of specimens on black and on white backgrounds contained red and white pigment dispersing and concentrating hormones. As anticipated, the blood of specimens from a black background contained more red pigment dispersing and less red pigment concentrating hormone than the blood of specimens from a white background. However, consideration of the results obtained with the white chromatophores revealed that the major difference between the bloods of specimens from black and from white backgrounds was that the blood of specimens adapted to a black background contained more white pigment concentrating hormone than blood of specimens from a white background. Blood of both groups of crawfish contained about the same amount of white pigment dispersing hormone. This unexpected result was possible if *Orconectes* maintained the titer of white pigment dispersing hormone relatively constant and achieved adaptation of the white pigment primarily by means of alterations in the titer of white pigment concentrating hormone. A similar situation might have prevailed in the case of the red pigment in view of the small difference in titer of red pigment concentrating hormone in the crawfish on the black and white backgrounds. The degree of red pigment dispersion would have depended primarily upon the blood concentration of red pigment dispersing hormone.

DISCUSSION

The experiments described above revealed that the chromatophore system of *Orconectes clypeatus* differed from those of *O. immunis* and *Cambarellus shufeldti* in several respects. Probably the most striking difference was the inability of *Orconectes clypeatus*

under ordinary conditions to concentrate maximally its red pigment whereas the other two species had no apparent difficulty in this regard. Inability to concentrate maximally the red pigment was in all probability due in part to insufficient release of red pigment concentrating hormone from the eyestalks and central nervous organs and not to the inability of the red pigment to concentrate maximally since maximal red pigment concentration was induced by injection of tissue extracts (Fig. 3).

Inspection of Fig. 3 also revealed that the same extract induced a more marked pigment concentration in crawfish with maximally dispersed red pigment than in crawfish with red pigment in an intermediate condition when the hormones were injected. Evidently, the initial stage of the chromatophore determined in part the degree of response to chromatophorotropin. A similar observation was made by Fingerman (1957b) in the study of isolated chromatophores of *Cambarellus* where the responses of the red and white pigments to tissue extracts depended in part upon the initial stage of the pigment.

Responses of red and white chromatophores on isolated portions of carapace of *Cambarellus* differed from the responses observed with carapace fragments of *Orconectes clypeatus* (Fig. 5). Two hours after isolation the white pigment of *Cambarellus* was between stages 4 and 5, the red between 1 and 2.2 (Fingerman, 1957b). The white pigment of *Orconectes clypeatus* was between 2.8 and 4.2 two hours after isolation and the red pigment between 2.4 and 3.3. Evidently the red and white pigments of *Cambarellus* had "resting states" closer to the extremes, stages 1 and 5 respectively, than did the pigments of *Orconectes* where the "resting state" appeared to be an intermediate degree of pigment dispersion.

The two methods of assay of tissue extracts, injection into one-eyed specimens and direct application to isolated chromatophores, complemented each other. Chromatophorotropins that were not evident with one technique were demonstrated by the other, e.g., red pigment dispersing hormone of *Orconectes* was evident only when tissue extracts were applied to isolated chromatophores but not when the extracts were injected into one-eyed individuals.

The simultaneous presence of pigment dispersing and concentrating hormones in the blood of *Orconectes clypeatus* confirmed the results of Fingerman (1957b) for the blood of *Cambarellus*. The hormonal blood picture appears to be quite different in crawfishes and shrimp because Koller (1925, 1927) found but one hormone in the blood controlled the melanophores of *Crago vulgaris*. The results of Koller, however, may be erroneous since Brown and Klotz (1947) demonstrated by chemical fractionation that the tritocerebral commissure of *Crago septemspinosus* produced two mutually antagonistic chromatophorotropins, a general darkening one and a body lightening one.

The thoracic nerve cord of *Orconectes clypeatus* was the most potent source of red and white pigment concentrating hormones (Figs.

3 and 4). McVay (1942) found the same was true of the thoracic nerve cord of *Orconectes immunis*. The thoracic nerve cord was the most potent source of white pigment concentrating hormone in *Cambarellus shufeldti* but the circumesophageal connectives were the most potent source of red pigment concentrating hormone (Fingerman, 1957a). Evidently among the crawfishes investigated no consistent trend exists with respect to the most potent source of chromatophorotropins. A survey of the literature likewise showed no consistent trend with regard to black pigment dispersing activity among the crabs investigated (Fingerman, 1956).

SUMMARY

Background responses of the crawfish *Orconectes clypeatus* have been investigated. On a black background the white pigment concentrated maximally and the red pigment dispersed maximally. On a white background the white pigment dispersed maximally but the red pigment assumed an intermediate degree of dispersion.

Maximal red pigment concentration did not occur in specimens kept under constant illumination on a white background for 32 days.

The eyestalk produced red pigment dispersing and concentrating hormones and white pigment concentrating hormone. A white pigment dispersing hormone may also be secreted.

The central nervous system produced red and white pigment dispersing and concentrating hormones.

The blood contained at all times red and white pigment dispersing and concentrating hormones. The stage of the pigments appeared to depend upon the relative concentrations of the dispersing and concentrating hormones.

The degree of pigment dispersion determined in part the degree of response to chromatophorotropin. A greater degree of pigment concentration in response to the same extract occurred when the red pigment was maximally dispersed than when in an intermediate degree of dispersion.

The endocrine control of crawfish chromatophores was discussed.

REFERENCES

BROWN, F. A., JR., AND I. M. KLOTZ 1947—Separation of two mutually antagonistic chromatophorotropins from the tritocerebral commissure of *Crago*. Proc. Soc. Exp. Biol. Med. 64:310-313.

——— AND A. MEGLITSCH 1940—Comparison of the chromatophorotropic activity of insect corpora cardioca with that of crustacean sinus glands. Biol. Bull. 79:409-418.

———, H. M. WEBB, AND M. I. SANDEEN 1952—The action of two hormones regulating the red chromatophores of *Palaemonetes*. J. Exp. Zool. 120:391-420.

FINGERMAN, M. 1956—Physiology of the black and red chromatophores of *Callinectes sapidus*. J. Exp. Zool. 133:87-106.

———1957a—Endocrine control of the red and white chromatophores of the dwarf crawfish, *Cambarellus shufeldtii*. Tulane Stud. Zool. 5:137-148.

———1957b—Physiology of the red and white chromatophores of the dwarf crawfish, *Cambarellus shufeldtii*. Physiol. Zool. 30:142-154.

HOGBEN, L. T., AND D. SLOME 1931—The pigmentary effector system. VI. The dual character of endocrine coordination in amphibian colour change. Proc. Roy. Soc. Lond., Ser. B 108:10-53.

KOLLER, G. 1925—Über den Farbwechsel bei *Crangon vulgaris*. Verh. deutsch. Zool. Gesell. 30:128-132.

———1927—Über Chromatophorensystem, Farbensinn und Farbwechsel bei *Crangon vulgaris*. Zeit. vergl. Physiol. 5:191-246.

MCVAY, J. A. 1942—Physiological experiments upon neurosecretion, with special reference to *Lumbricus* and *Cambarus*. Doctorate Thesis, Northwestern University, Evanston, Illinois.

Comparative Studies of Developmental Rates, Hibernation, and Food Plants in North American Colias (Lepidoptera, Pieridae)[1]

SHIGERU ALBERT AE
University of Notre Dame, Notre Dame, Indiana
& Yale University, New Haven, Connecticut[2]

Many studies have been done on *Colias* life histories. However, little work has been reported on the results of rearing in constant conditions and the writer was unable to find any reports of successful attempts to get a second generation of *Colias* among the species which, in nature, have one generation a year.

Developmental rates are usually species-specific. At the same time, they are affected extensively by various environmental factors. Therefore, it is essential in obtaining data on interspecific differences in developmental rates to carry out the rearing under constant conditions. Developmental rates for the fastest growing larvae of 6 North American species of *Colias*, reared under constant conditions, were recorded (Ae, 1956). The writer succeeded also in obtaining second generation butterflies in the 4 species which are univoltine in nature. At the same time, characteristics of hibernation, important for survival of the species, were studied.

The reduction of egg fertility was observed for wild females of *Colias* that had been kept in a cold room. Some new information on food plants was also obtained. The writer's field collections, at and near Gothic, Colorado, provided data on seasonal isolation of *Colias* species in nature.

Acknowledgment.—The writer wishes to express his sincere gratitude to Dr. Edward O. Dodson, Department of Biology, University of Ottawa, and Dr. Charles L. Remington, Department of Zoology, Yale University, for direction of the research and for aid in writing this paper. The writer is also grateful to the following: Dr. A. E. Brower, Dr. C. L. Remington, and Mr. B. Mather, for providing living material; and to Dr. M. L. Shubert for identifying food plants.

The writer also wishes to acknowledge the Rocky Mountain Biological Laboratory for facilities given.

Materials and Methods

The species used in this work are *Colias alexandra* Edwards (from Gothic, Gunnison County, Colorado); *C. eurytheme* Boisduval (from

[1] Part of this work was presented as a dissertation in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Notre Dame.

[2] Present address—Nanzan University (the Catholic University of Nagoya), Showaku, Nagoya, Japan.

Notre Dame, Indiana; New Haven, Connecticut; and Jackson, Mississippi); *C. interior* Scudder (from Cheboygan, Michigan, and Saddleback Mountain, Maine); *C. meadii* Edwards (from Gothic); *C. philodice* Latreille (from Notre Dame, New Haven, and Gothic); and *C. scudderi* Reakirt (from Gothic). While *C. alexandra, C. interior, C. meadii,* and *C. scudderi* have one generation a year, *C. eurytheme* and *C. philodice* have two to several generations a year. Larvae of *C. alexandra, C. eurytheme, C. meadii,* and *C. philodice* feed on legumes such as clovers, alfalfa, and vetch. *C. interior* feeds on blueberry, and *C. scudderi* on willow. However, the experimental survey of the food plants of these species has not yet been completed. Their wing patterns resemble one another very closely, and in the range of variation of several characters, they often overlap. Therefore, although typical specimens are readily classified by combinations of alar characters such as ground color, black borders, and color of fringes and hind wing discal spots, unclassifiable specimens occur.

Eggs were obtained from females in cages containing the food plants or in glass lamp chimneys on potted food plants. These containers were placed under the sun or near an incandescent lamp.

For the rearing of larvae, insect cages, about 30 cm cubed, were used. Potted seedlings or plants were usually used as larval food. The main food plants used were white clover, alfalfa, vetch, blueberry, weeping willow and pussy willow. Larvae were reared in the greenhouse and in the rearing room of the Department of Biology, University of Notre Dame, in rearing rooms of the Josiah Willard Gibbs Research Laboratory at Yale University, and in the Johnson Research Laboratory of the Rocky Mountain Biological Laboratory. The rearing room of the University of Notre Dame was kept at 80° F, 65% R.H., and 15 hours fluorescent light illumination a day. The rearing room of the Gibbs Laboratory was kept at 80° F and 14 hours fluorescent light illumination a day. The conditions in the other laboratory were not as precisely controlled.

During the rearing, a large number of larvae and pupae often died. Larvae usually became soft, brownish-black, decaying masses, after their color had changed to lighter green. Pupae usually changed black and dried up if they were left untouched. These symptoms coincide precisely with the description of Steinhaus (1949) concerning polyhedroses by virus infection in *Colias*. Therefore, these losses are referred to simply as virus disease in this paper, although microscopic tests were not performed. Other diseases caused by fungi and bacteria seemed to be negligible.

DEVELOPMENTAL RATES

The developmental rates of 6 North American *Colias* species were studied under the constant conditions. The rates of the fastest developing individuals were recorded. Because of irregular death rates due to virus diseases during development, reliable data on average and slowest developmental rates could not be obtained.

Tables I and II show the results of Experiments 1 and 2 respectively. Experiment 1 was conducted in the rearing room at Notre Dame. The *C. eurytheme* and *C. philodice* were progeny reared from local wild females. *C. alexandra* and *C. scudderi* were sent from Gothic by Dr. C. L. Remington, and *C. interior* was sent from Saddle-back Mountain by Dr. A. E. Brower. Eggs were obtained in the greenhouse and moved to the rearing room before eclosion, except for *C. interior*, of which larvae were moved to the rearing room at the beginning of their 3rd instar. Experiment 2 was conducted at Yale University. The mothers of the broods for *C. meadii*, *C. scudderi*, and *C. p. eriphyle* were brought by the writer from Gothic. Local *C. p. philodice* and *C. eurytheme* were used as the mothers of the broods of these species. The results from these data indicate that *C. eurytheme* and *C. philodice* have the same developmental rate. *C. alexandra*, *C. meadii*, *C. scudderi*, and *C. interior* are slower than the other two species. Unfortunately only one individual from each of the broods of *C. scudderi* and *C. interior* became an adult. A few more larvae in the 1955 broods reached the 4th and 5th instar with approximately the same developmental rates as the individual which emerged in each case. However, they were killed by virus disease. Only one egg was obtained from *C. scudderi* in 1956. *C. p. eriphyle* and *C. p. philodice* on white clover had the same developmental rate but were slower than the ones on vetch. The developmental rate of *C. meadii* on white clover seems also slower than the one on vetch.

In order to examine the differences of the developmental rates

TABLE I.—Fastest developing individuals in five species of *Colias*, 1955 80°F, 65% R.H., 15 hours light a day (Notre Dame)

	Species, Broods, Food Plants				
Days from hatch to:	*eurytheme* W-60 Vetch	*philodice* W-69-8-7 Vetch	*alexandra* A-2 Vetch	*scudderi* S-1 Weeping willow	*interior* I-16 Blueberry
1st molt	2	2	3	3	9
2nd molt	3	3	6	10	15
3rd molt	4	4	7	18	19
4th molt	6	5	9	22	23
Prepupation	7	7	10	28	30
Pupation	8	8	11	29	31
Emergence	12	12	17	34	37
Sex	male	male	male	female	female
Other sex*	13	13	23	—	—

* Fastest developing individuals of the slower developing sex (hatch to emergence).

TABLE II.—Fastest developing individuals in four species of *Colias*, 1956 80°F, 14 hours light a day (Yale)

	Species, Broods, Food Plants				
Days from hatch to:	*eurytheme* P-67 Vetch	*philodice philodice* P-53 Vetch	*philodice eriphyle* P-52 Vetch	*meadii* M-7 Vetch	*scudderi* S-10 Pussy willow
1st molt	2	2	2	5	4
2nd molt	4	4	4	10	8
3rd molt	5	5	5	12	13
4th molt	7	7	7	15	17
Prepupation	9	9	10	19	21
Pupation	10	10	11	20	22
Emergence	15	16	16	25	28
Sex	male	male	both	female	male
Other sex	17	17	—	—	—
White clover diet*					
male		22	22	29	
female		—	—	28	

* Hatch to emergence.

among different broods within the same species, the developmental rates were followed for six broods of *C. eurytheme* in the rearing room at Notre Dame (Table III). These indicate very little variation in developmental rates, as far as the most rapid growing larvae are concerned.

HIBERNATION

During the above rearings, it was found that *C. alexandra, C. interior, C. meadii,* and *C. scudderi,* which in nature have one generation a year, produced a second generation under conditions of 14-15 hours light illumination a day and 80°F.

As shown in Tables I and II, they produced the second generation without any resting stages. However, some of their larvae started to hibernate under the above conditions, just as they do in the greenhouse or in nature.

In Experiment 1, most *C. interior* larvae began to hibernate at the 3rd instar while several larvae continued to grow. No larva of *C. scudderi* started to hibernate and more than half of the larvae were lost before their 3rd instar. The initial number of fertile eggs was 12. In the case of *C. alexandra,* one group was reared on vetch (about 12 fertile eggs) and another on white clover (16 fertile eggs). None hibernated among the larvae reared on vetch, although a few were lost

before the 3rd instar. All larvae reared on white clover started to hiberate in the 3rd instar.

In Experiment 2, all *C. alexandra* larvae (more than 12) which were reared on vetch started to hibernate in the 3rd instar, as did one *C. meadii* larva. These hibernating larvae were kept in the rearing room continuously. After about 35 days, the *C. meadii* larva started to feed again, but died after 2 days without having another molt. One *C. alexandra* larva began to feed again after 70 days, and it continued to eat very slowly for about one week, but died without having another molt. Without starting to feed again, other larvae died between one and two months after starting to hibernate, some probably killed by diseases.

It is known that while *C. philodice* has a distinct hibernating stage, *C. eurytheme* continues to grow in winter. Therefore, in order to clarify this difference between *C. eurytheme* and *C. philodice*, 44 fertile eggs of *C. philodice* (P-60) and 43 fertile eggs of *C. eurytheme* (P-62) were placed on the roof of the Gibbs Laboratory on 3 October, 1956. The *C. philodice* started to lay eggs several hours earlier than the *C. eurytheme*. The pots of white clover, on which the eggs had been laid, were placed in insect cages when they were brought to the roof.

The eggs of *C. philodice* hatched on 7 October and those of *C. eurytheme* on 8 October. The developmental rates of larvae of both species were very slow, but were equal and constant. They reached the 2nd instar on 16 and 17 October respectively, and the 3rd instar on 27 and 28 October respectively. These were the records of the fastest growing larvae, and at least a few others molted on the same day. No differences in the developmental rates between the two species were observed up to this point. However, *C. philodice* larvae started to hibernate soon, one by one, while *C. eurytheme* larvae continued to grow. Although the first larva of each species reached the 4th instar on 12 November, on 28 November, 22 hibernating 3rd instar and 9

TABLE III.—Fastest developing individuals in six 1956 broods of *C. eurytheme* 80°F, 65% R.H., 15 hours light a day (Notre Dame)
Food plant — Vetch

Days from hatch to:	Broods					
	P-1	P-2	P-3	P-5	P-7	P-10
1st molt	1	2	2	2	2	2
2nd molt	3	3	3	3	3	3
3rd molt	4	4	4	4	5	5
4th molt	6	6	6	6	7	6
Prepupation	7	8	8	7	8	8
Pupation	8	9	9	8	9	9
Emergence	13	14	13	12	14	13
Sex	both	both	both	male	male	male
Other sex	—	—	—	13	15	14

TABLE IV.—Egg fertility of wild *Colias* kept in 60° F room

Brood	Species*	Within First Two Weeks		Later	
		No. of eggs laid	Fertility %	No. of eggs laid	Fertility %
P-60	P	151	96		
P-61	E	140	99		
P-62	E	43	100	22	64
P-63	P	166	99		
P-66	E			229	46
P-67	E	61	100		
P-68	P	56	100		
P-69	P			46	59
P-71	E			92	40
P-72	E			123	80
P-73	P	38	100		
P-74	E	43	100		
P-75	E			87	59
P-76	P			130	73
P-77	E	35	100		
P-78	E	29	100		
Total		762	99.0	729	58.6

* P = *C. philodice;* E = *C. eurytheme.*

hibernating 4th instar were found in the *C. philodice* group, while 2 larvae in the end of the 3rd instar and 14 4th instar larvae were found in the *C. eurytheme* group. All of the 4th instar larvae of *C. eurytheme* were apparently feeding, although very slowly. Since food plants were eaten extensively and also damaged by the cold weather by this time, 14 3rd and 7 4th instar larvae of *C. philodice* and 9 4th and 2 3rd instar larvae of *C. eurytheme* were moved to new vetch seedlings and were kept on the roof continuously.

The other larvae were moved to the rearing room. While the *C. eurytheme* larvae started to feed immediately, the *C. philodice* larvae remained still for about three days and acquired the form of the end of the 3rd or 4th instar without feeding and molted normally. Adults were obtained from both groups.

On the roof, due to the severe weather, the edible leaves of the vetch seedlings were gone by the end of the year. Many larvae of both species were killed presumably by the severe winter conditions. None of the *C. eurytheme* transformed into a typical hibernating form, although some of them resembled it. On 7 February, 9 healthy *C. philodice* larvae of the 3rd instar were found, while no survivor was found in the *C. eurytheme* group.

These 9 larvae were moved to the rearing room. They started to feed the next day, and some of them molted on 9 February. Some of these reached the 5th instar, but none survived the 5th instar stage, because of virus diseases.

The form of hibernating larvae of the above 5 species somewhat

TABLE V.—Comparison of external characters of hibernating *Colias* larvae

Characters	Species			
	alexandra	*meadii*	*philodice*	*scudderi*
ground color	Kildare Green with many small melanin spots			
dorsal line	present	present	present	present
middorsal line	absent	present	absent	absent
spiracular line	white, very scant	white	white, some with pink spots	greenish white
head color	a little darker than body	much darker than body	the same as body	a little darker than body
setae on body	many white, club-shaped; some black, bristle-shaped	long, black, bristle-shaped	long, black, bristle-shaped	short, black, bristle-shaped
setae on head	the same as body	the same as *alexandra*	the same as body	the same as *alexandra*

resembled the pre-ecdysial form of the end of an instar. However, the epidermis is not as tense as the pre-ecdysial stage. For each of the following, 5 to 10 hibernating larvae were compared externally: *C. alexandra, C. meadii,* and *C. scudderi* at Gothic and *C. philodice* in New Haven. The results of the observations are described above. Each species could be distinguished clearly by the combinations of observed characters and also differed from their feeding stages in their general form (Table V).

REDUCTION OF EGG FERTILITY OF WILD FEMALES KEPT AT LOW TEMPERATURE

The normal egg fertility of *C. eurytheme* and *C. philodice* varies from 96 to 100 percent (see Hovanitz, 1944, and Table IV of this paper). In the writer's experiments, freshly caught wild females of *C. eurytheme* and *C. philodice* always had high fertility. However, when they were kept in a room at 60° F with dim light and fed every other day, a noticeable reduction of egg fertility was observed. Table IV shows the results. Turning of egg color from white to red was used as an indication of a successful fertilization. Since *Colias* lays a large number of eggs within a day, females were used for one or two days (several hours each) at a time for egg laying at 80° F and they were

TABLE VI.—Recovery of egg fertility of wild *Colias* kept in 60° F room

Brood	Days Kept In 60°F Room	Fertility %	No. of eggs laid
P-69	14	37.5	24
	16	81.8	22
P-76	18	43.1	58
	20	96.6	29
	21	97.7	43

kept continuously at 60° F when they were not being used for oviposition. While some females were used within one or two days after they were collected, others were kept for more than two weeks without being confined for oviposition. Although egg fertility was recorded for each day, no definite period at 60° F was found which was necessary for reduction of egg fertility. Therefore, the division of before and after their collections in Table IV is arbitrary. When wild females were allowed to lay eggs for a few successive days after their egg fertility had decreased, the recovery of higher egg fertility was usually observed (Table VI).

FOOD PLANTS

The writer observed 6 different orange *C. meadii* females laying their eggs on *Astragalus alpinus* between 3 and 13 August near Gothic (Table VII). The region in which this observation was made was between the first and second river-crossing of the trail toward Copper Lake from Gothic. The usual alpine food plant of *C. meadii* was not found in this region, because this place is far below the usual altitude of *C. meadii*. In captivity, *C. meadii* reared on *A. alpinus* reached the 3rd instar. Rearing was discontinued in this stage, because the writer left the Rocky Mountain Biological Laboratory at this time. It is fairly certain that at low altitudes *A. alpinus* is one of the food plants of *C. meadii*. Female No. 3 (Table VII) laid 2 eggs on *Vicia americana* before it laid 4 eggs on *A. alpinus*. *A. alpinus* and *V. americana* are both common in the region in which the observation was made.

Experiments on the choice of food plants by egg laying *Colias* fe-

TABLE VII.—Egg laying of wild, unconfined *C. meadii* on *Astragalus alpinus* Above Gothic, Colorado

Butterflies	No. of eggs laid	Date of observation
No. 1	1	(August) 3
No. 2	2	5
No. 3	4	6
No. 4	1	6
No. 5	1	7
No. 6	2	13

males were performed at the Rocky Mountain Biological Laboratory August 1956, using 30 cm cubed cages, of which 4 sides and the top were copper netting. Four different kinds of plants, namely white clover (*Trifolium repens*), blueberry (*Vaccinium myotillus*), willow (*Salix brachycarpa*), and weeds (grass and wild chrysanthemum used as controls) were placed in the cages under the sun. The plants were placed so that they did not touch, and approximately equal leaf areas were available. The cage was rotated so that each side received equal sun. The results are shown in Table VIII. Although more confirmatory data are necessary, it is noticeable that *C. scudderi* laid eggs on willow, blueberry, and white clover, while *C. p. eriphyle* and *C. meadii* concentrate their eggs on white clover. *C. scudderi* larvae were reared successfully until the 3rd instar on willow, blueberry, and white clover, although most of the larvae left white clover when they hatched, while the others remained and started to feed immediately on willow and blueberry. The rearing experiments had to be discontinued at the 3rd instar. The identification of the above 5 plants in this section was verified by Dr. M. L. Shubert.

In the spring of 1956 experiments were conducted in the rearing room at Notre Dame to determine whether *C. eurytheme* larvae could survive on dwarf pussy willow and blueberry. Only young leaves were used for the experiment. Ninety-three (43 just after hatching 20 end of the 3rd instar, 10 beginning of the 4th instar, 10 end of the 4th instar, and 10 middle of the 5th instar) were placed on young pussy willow leaves which were in plastic containers. A few larvae started to feed; however, none of them was able to survive long enough to show any development. The same results were observed for larvae which were placed on young blueberry leaves in plastic containers; 92 (42 just after hatching, 20 end of the 3rd instar, 10 beginning of the 4th instar, 10 end of the 4th instar, and 10 middle of the 5th instar) were used on blueberry.

SEASONAL ISOLATION IN COLIAS

At the Rocky Mountain Biological Laboratory and its vicinity, *C. alexandra, C. philodice eriphyle,* and *C. scudderi* are commonly

TABLE VIII.—Experiments with the choice of oviposition plants by *Colias* females

Species	No. of Individuals	No. of Eggs Laid On				Hours of Egg Laying
		white clover	willow	blueberry	weeds (controls)	
C. scudderi	3	9	28	10	1	9
C. scudderi	3	4	15	1	3	7½
C. p. eriphyle	2	12	0	0	0	6
C. p. eriphyle	2	38	0	0	0	7
C. meadii	3	35	0	0	0	9

found. *C. eurytheme* and *C. meadii* are also found but they are not common. Although they are found at the same time on many occasions, field collections by the writer clearly show their relative seasonal isolation. Table IX illustrates the situation. The first generation of *C. p. eriphyle* appears in June. However, when *C. alexandra* and *C. scudderi* appear in this region in the beginning of July, *C. p. eriphyle* are already becoming uncommon. The writer was unable to find any *C. p. eriphyle* in the middle and last part of July, when *C. alexandra* and *C. scudderi* were common in this region. In the beginning of August, the second generation of *C. p. eriphyle* comes out in this region. However, at this time, the *C. alexandra* and *C. scudderi* populations are decreasing very rapidly.

TABLE IX.—A sampling of *Colias* at Gothic, Colorado, 1956

Period	Species					
	C. p. eriphyle		*C. alexandra*		*C. scudderi*	
	male	female	male	female	male	female
July 2-10	10	1	26	13	9	4
July 11-20	0	0	12*	6*	4*	2*
July 21-31	0	0	11*	13*	6*	3*
Aug. 1-10	2	2	2	1	1	3
Aug. 11-20	28*	5*	0	1	0	2
Aug. 21-27	16*	5*	0	0	0	0

* Many more were seen than collected.

The same seems to be true of C. *meadii* and *C. p. eriphyle* at the region between the first and the second river-crossing toward Copper Lake from Gothic. Although this place has a lower altitude than the usual *C. meadii* habitat, the population of *C. meadii* in this region is large. The writer did not observe the first generation of *C. p. eriphyle,* which may appear at the end of June or the beginning of July. No *C. p. eriphyle* was seen from the middle of July to the beginning of August, when *C. meadii* was common. When *C. p. eriphyle* appeared in this region in the middle of August, the *C. meadii* population had already become very small.

DISCUSSION

The equal developmental rates of *C. eurytheme* and *C. philodice* may be one indication of close relationship of the two species. It is necessary to compare mean developmental rates and standard deviations of the two species for more accurate observation. However, since the fastest developmental rates of 6 broods of *C. eurytheme* under the same conditions are fairly constant, these may indicate the regular upper limit of developmental rates of the species under these conditions.

In general, any differences in developmental rates of the 6 studied

species seem to depend upon differences of food plants. Larvae grow most rapidly on vetch seedlings, less rapidly on white clover, and very slowly on willow and blueberry; this may mean that they develop more rapidly on softer leaves. However, *C. alexandra* and *C. meadii* have slower developmental rates than *C. eurytheme* and *C. philodice* on vetch seedlings. This is apparently an interspecific, hereditary difference of the developmental rates.

Acceleration of larval developmental rates by crowded conditions was reported in *Pieris brassicae* and a few moths (Long, 1953). The population densities of the writer's experiments were not equal. However, the developmental rates of *C. scudderi* and *C. interior* were far slower than the decrease observed by Long in solitary conditions in comparison with crowded conditions. The larval density of *C. alexandra* and *C. meadii* did not differ notably from that of *C. eurytheme* under the same conditions. Therefore, the results obtained by the writer in these cases could not be due simply to density differences.

The most striking differences in life history between mountain or northern species and more widely distributed species are in the characteristics of hibernation and voltinism. *C. alexandra, C. interior, C. meadii C. scudderi* have one generation a year and hibernate in the 3rd instar. *C. eurytheme* and *C. philodice* have more than one generation a year, even at high altitudes in Colorado. While *C. eurytheme* continues to grow slowly during the winter if it survives at all, *C. philodice* hibernates in a somewhat distinctive resting state, like mountain or northern species (see Hovanitz, 1943). The writer's rearings of the two species on the laboratory roof in fall and winter give additional relevant data.

Hibernation of larvae of some of these species may be a true diapause. However, since no clear evidence of this has yet been obtained, the inclusive term hibernation was used in this paper. The somewhat distinct overwintering form of four *Colias* species, described above, may be supporting evidence for diapause; yet this could be an extremely contracted form of normal feeding larvae and could be a reaction without true diapause to the environmental conditions.

In conditions of 14-15 hours light a day and 80° F, *C. alexandra, C. interior, C. meadii,* and *C. scudderi* produce at least a partial second generation of the year. It was found that a large number of *C. interior* larvae from females from Cheboygan and one *C. alexandra* larva went into the hibernating phase in the summer without exception under the high temperature of the greenhouse at Notre Dame (80-100° F). However, the writer's experiments have not yet produced sufficient evidence to show whether 14-15 hours light a day can alone prevent hibernation without coupling it with high temperature. It is puzzling that, at 14-15 hours light and 80° F, some larvae started to hibernate and others did not hibernate at all. Further observations show that larvae which were reared with young fresh leaves of food plants usually went through without hibernation. These observations agree with Grison's (1947) work in *Euproctis,* in which he succeeded

in preventing diapause of larvae feeding on young apple leaves. The condition and perhaps species of food plants may also be controlling factors for hibernation in *Colias*.

In the case of *C. alexandra*, only larvae reared on vetch at 15 hours light and 80° F went through without hibernation, but none of them on white clover at 15 hours light and 80° F, nor on vetch at 14 hours light and 80° F, could become adults without hibernation. White clover leaves which were used here were much harder and older than the vetch leaves, which were tender and fresh, and the condition of the white clover may be the cause of hibernation. At the beginning of the experiment with 14 hours light, illumination was provided by filament bulbs whose intensity was much lower than the fluorescent lights used later and in the 15 hours experiments. In this case, the poor lighting period could have been the cause of hibernation.

Decreases of egg fertility with age in various genotypes of *Drosophila melanogaster* were reported by Hadorn and Zeller (1943). It is difficult to decide whether the age of adults or low temperature (60° F) induced the decrease of fertility in the writer's experiment in *C. eurytheme* and *C. philodice*. However, a clear tendency for recovery of egg fertility was observed when females were allowed to lay eggs continuously after they had once lost their high egg fertility because of prolonged treatment at 60° F. Therefore, the 60° F temperature may be at least partially responsible for this decrease.

Similarity or diversity of food plants among the closely related species is an important factor for analyzing the relations between species. For an accurate analysis of these relations, careful studies must be made particularly of preferred plants among all the food plants of each species of *Colias*, and of mortality of larvae and fertility of adults for each food plant. The writer's data on food plants will add some light for such an analysis. The fact that *C. scudderi* lays eggs on any of the three major food plants of *Colias*, and can survive on all at least till the 3rd instar may suggest that food plant differentiation in *Colias* may have had its origin quite recently, at least in some species. *A. alpinus* is known as food plant of *C. hecla* Lefebre, which is a species related to *C. meadii*. Therefore, the fact that *C. meadii* seems to prefer *A. alpinus* among the many legumes at low altitudes may give another evidence for a close relationship between these two species.

Isolating mechanisms among sympatric *Colias* species may also help in a study of relationships among species. The present data on seasonal isolation in *Colias* are on this line.

Many data presented in this paper need to be followed by detailed studies in order to lead to final conclusions. However, since the writer may not be able to extend most of these experiments in the near future, the data are presented here so that they will be available to other workers.

SUMMARY

The developmental rates of *C. eurytheme* and *C. philodice* are

the same and are the fastest among the six species used. The developmental rates of *C. alexandra* and *C. meadii* are somewhat slower than the above two species. The developmental rates of *C. interior* and *C. scudderi* are much slower than the above four species.

Although *C. alexandra, C. interior, C. meadii* and *C. scudderi* have one generation a year in nature and hibernate in the third instar, a second generation of butterflies was produced the same year, at 14-15 hours light a day and 80° F, probably correlated with fresh food plants.

The fact that *C. philodice* has a distinctive hibernating larval form and *C. eurytheme* continues to grow slowly in winter was confirmed.

Hibernating larvae of *C. alexandra, C. meadii, C. philodice,* and *C. scudderi* were described.

Reduction of egg fertility of wild females of *C. eurytheme* and *C. philodice* kept at 60° F was observed.

Oviposition of wild *C. meadii* on *Astragalus alpinus* was observed in Colorado, and larvae of *C. meadii* were reared satisfactorily on this plant until the 3rd instar.

In oviposition choice experiments in the presence of white clover, blueberry, willow, and a control (weeds which are not food plants of any *Colias*), *C. scudderi* laid eggs on willow, blueberry, and white clover in considerable numbers. However, *C. p. eriphyle* and *C. meadii* concentrated their eggs on white clover.

Large numbers of larvae of various instars of *C. eurytheme* failed to survive on young leaves of blueberry and pussy willow.

Comparative seasonal differences in flight period were observed between *C. p. eriphyle* and *C. alexandra* and *C. scudderi* and between *C. p. eriphyle* and *C. meadii* at Gothic, Colorado, and its vicinity.

REFERENCES

AE, S. A. 1956—Hybrids between *Colias eurytheme* and *C. interior*. Lepid. News *10*:9-14.

GRISON, P. 1947—Developpement sans diapause des chenilles de *Euproctis phaeorrhaea* L. C. R. Acad. Sci. *225*:1089-1090.

HADORN, E., AND H. ZELLER 1943—Fertilitatsstudien an *Drosophila melanogaster*, I. Untersuchungen zum altersbedingten Fertilitatsabfall. Arch. Entw. Mech. *142*:276-300.

HOVANITZ, W. 1943—Hybridization and seasonal segregation in two races of a butterfly occurring together in two localities. Biol. Bull. *85*:44-51.

———1944—Genetic data on the two races of *Colias chrysotheme* in North America and on a white form occurring in each. Genetics *29*:1-30.

LONG, D. B. 1953—Effects of population density on larvae of Lepidoptera. Tran. Roy. Ent. Soc. London *104*:541-591.

STEINHAUS, E. A. 1949—*Principles of Insect Pathology* 477-485.

Observations on the Seasonal Occurrence of a Pseudophyllidean Tapeworm Infecting the Alimentary Tract of Lepomis macrochirus macrochirus Raf. in Albemarle County, Virginia

BURTON J. BOGITSH[1]
University of Virginia, Charlottesville, Virginia

In an investigation of the helminths of fresh-water fish from ponds in Albemarle County, Virginia, the presence of a pseudophyllidean tapeworm infecting *Lepomis macrochirus macrochirus* Raf. was recorded. The parasite was recovered from the intestine and pyloric caeca of the fish host. The worm was assigned to the genus *Bothriocephalus* Rudolphi, 1808, on the bases of the nature of the scolex and the arrangement of internal organs in the proglottids. It resembles *B. rarus* Thomas which was described from the newt, *Trituris viridescens* Raf. (Thomas, 1937).

Little information regarding the seasonal occurrence of parasites is available in the existing literature. Most investigators are concerned with the number and types of parasites present in the host; few attempt to establish any correlation between the extent of infection and seasonal regularity. This correlation is especially significant when applied to a parasite that requires an intermediate host which in itself displays a periodicity of occurrence. It is possible, then, to correlate the seasonal variability of the worm with its degree of maturity within the host.

Materials and Methods

Fish were collected from artificial ponds by the use of seines and by angling. Collections were initiated in April, 1956 and spaced at intervals of approximately three months. Additional collections supplemented this program when it was evident that certain gaps had to be filled to present a more comprehensive picture of the seasonal occurrence of the parasite.

The study was based on stained and mounted specimens fixed in hot FAA.

Results

One hundred and eighty fish, ranging in total length from 6 cm to 15 cm (including caudal fin), were collected during the months of

[1] Present address: Department of Biology, Georgia Teachers College, Collegeboro, Georgia.

April and early May, 1956. Subsequent examination of the fish revealed a 17 percent incidence of infection with *Bothriocephalus sp.* All the parasites were in an advance plerocercoid stage with marked signs of strobilization. The average length of 25 specimens was 8.6 mm.

The collection and examination of 177 fish, 4-15 cm in total length, during the months of August and early September, 1956, revealed a 14 percent incidence of infected fish. All the worms were young larval forms showing little signs of development past the procercoid stage. The average length of 23 specimens was 1.3 mm thus indicating that the individuals must have achieved their maximum development in the late spring, probably in May or early June. The 183 fish, 4-10 cm, collected during the months of December, 1956, January and early February, 1957, displayed a 37 percent incidence of infection. All the tapeworms were plerocercoids with pronounced strobilization. The average length of 25 specimens was 5.4 mm.

Additional collections were made during June and July, 1957, with the following results. Thirty-seven fish collected in mid-June were uninfected; these fish ranged in size from 6-11 cm. Eight fish, 8-13 cm, collected in early July were infected with larval forms which averaged 0.4 mm in length.

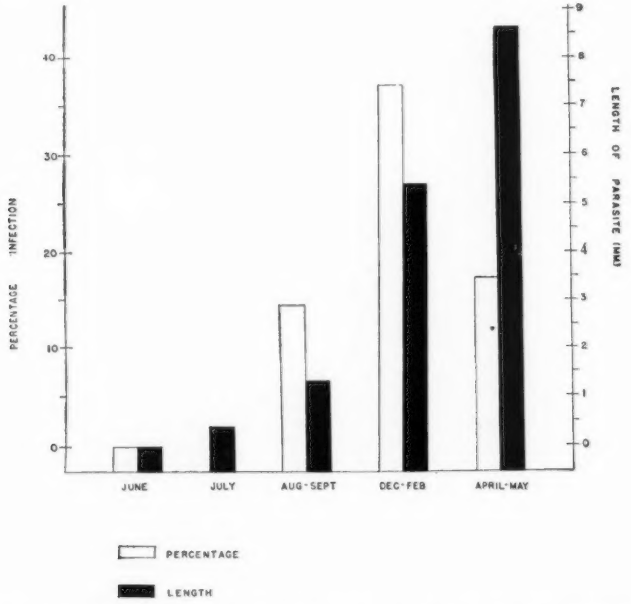


Fig. 1.—Seasonal incidence of occurrence and size of *Bothriocephalus* sp. in the host, *Lepomis m. macrochirus.*

DISCUSSION

From the preceding data, it must be concluded that this tapeworm cannot achieve sexual maturity in the alimentary tract of *Lepomis m. macrochirus*. The fish, therefore, either serves as an intermediate host or is accidentally parasitized.

Examination of Fig. 1 indicates the following: (1) the plerocercoid forms attain their maximum development in the spring, probably in May or early June; (2) the parasite is eliminated from the fish host in the middle of June, thus culminating a gradual decrease in the incidence of infection from the peak observed during the winter months; (3) the parasite is introduced into the fish host in late June or early July.

Further life cycle and host specificity studies are now in progress to determine the exact biology of this species of cestode; in addition, further detailed morphological studies will be presented at a later date to determine the exact systematic position of the worm, which (because of certain differences) the author does not believe to be a known species of *Bothriocephalus*.

REFERENCES

THOMAS, L. J. 1937—*Bothriocephalus rarus* n. sp. A cestode from the newt, *Trituris viridescens* Raf. Jour. of Parasitol. 23(2):119-132.

The Function of the Entepicondylar Foramen in Mammals

STUART O. LANDRY, JR.
University of Missouri School of Medicine, Columbia, Missouri

The entepicondylar foramen is a canal through the medial epicondyle at the distal end of the vertebrate humerus, usually traversed by the median nerve and brachial artery. This canal is frequently found in the humerus of mammals (Fig. 1).

The entepicondylar foramen is a primitive structure in mammals. Indeed, according to Romer (1945) it is a primitive amniote feature. He says (p. 168), "Most early reptiles possess an entepicondylar foramen, an opening for nerve and blood vessels on the back (or inner) side of the humerus near the distal end. Such a structure is found in a few primitive or reptile-like amphibians but is generally absent in that class."

The occurrence of the entepicondylar foramen in major mammalian groups has been surveyed by Gruber (1859), Giebel (1879), Baur (1887), Schlosser (1900), Stromer (1902), and Huntington (1918). The humeri of a dozen odd representative forms were dissected by Laugier (1923) and the occurrence of the foramen in various forms was noted incidentally by Leche (1900) and Muller (1904). The following survey is a synthesis of their results (sometimes contradictory), leavened by observations of my own.

Chiropterans, sirenians, cetaceans, proboscideans, hyracoids, perissodactyls, artiodactyls, and lagomorphs never have an entepicondylar foramen. Both living monotreme genera have one. In all other orders the occurrence of the foramen is variable.

Among the marsupials, the foramen is present in didelphids, wombats, and koalas, usually present in kangaroos and wallabies, and usually absent in dasyurids. It is absent in *Notoryctes* (the marsupial mole) and variable in occurrence in the phalangers. Other forms do not seem to have been investigated.

Among the insectivores; shrews, moles, and some species of hedgehog (*Erinaceus* and *Gymnura*) have an entepicondylar foramen. It is usually, however, reported as lacking in *Erinaceus europaeus*. The foramen is also present in *Tenrec*. Informaton on other insectivores is lacking.

Among the primates all of the prosimians (except *Perodicticus*) have the foramen and South American monkeys usually do. The Old World monkeys, apes, and man, usually do not.

In carnivores, among the Pinipeda the foramen is never found in the Otariidae or Odobenidae but is found rather often in the Phocidae. Among the Fissipeda the foramen is generally present in felids, mustelids, viverrids, and procyonids and generally absent in hyaenids,

canids, and ursids. Note that the occurrence of the entepicondylar foramen does not follow the superfamilial division of the suborder. In either the Canoidea or the Feloidea, forms whose limb structure is relatively primitive retain the entepicondylar foramen and forms whose limb structure is more specialized have lost the foramen.

Among both rodents and edentates the occurrence of the foramen is quite variable. It likewise varies in occurrence in the Pholidota where it is absent from one species, *Manis temminkii*, but presumably present in all the rest. The foramen is apparently variable in occurrence in the aard-vark (*Oryctoropus*) since Giebel (1879) reports it absent while Huntington (1918), reports it present.

This account of the occurrence of the entepicondylar foramen among mammals is purposefully sketchy, for the foramen may not occur consistently among all the members of the same species. Since all of the above accounts are based upon the examination of a few individuals (at most) of each species, the results are not completely trustworthy. The survey is intended only as a general guide to correlation of the loss of this foramen with limb adaptation in an attempt to determine the original function of the foramen. I emphasize that we must expect no absolute correlation between structure and function for the foramen may occur erratically among closely related forms.

I am presently surveying the occurrence of the entepicondylar foramen among rodents where I find that the foramen may be consistently absent throughout a suborder, present in one family of a superfamily and absent in another, absent in a given genus of a family, a given species of a genus, a given race of a species, or present on one side and absent on the other in the same individual.

The entepicondylar foramen is not found in man, but fairly frequently (in about 2 percent of white cadavers according to Struthers, 1881) a bony spur is found on the medial side of the humerus near its distal end (Fig. 1). This spur, known as the supracondyloid process, is continued by a ligamentous band to the medial epicondyle (Fig. 2). The process and its ligamentous connection are homologous with the arch forming the superficial wall of the entepicondylar foramen in other mammals. This arch does not seem to have been named, so I propose to call it the entepicondylar arch.

When a supracondyloid process and ligament exist in man the median nerve and brachial artery run beneath this bony-ligamentous bridge before emerging in the antecubital fossa exactly as the same structures pass beneath the entepicondylar arch in other mammals (Figs. 1 and 2).

The entepicondylar foramen in mammals, according to Gruber (1859), was first described by V. Coitier (1573). The supracondyloid process in man was discovered and figured for the first time by Tiedemann (1822). Otto (1839) first pointed out that the supracondyloid process was the homologue of the entepicondylar arch. The same observation was made independently by Knox (1841).

The widespread occurrence of this structure and the rather com-

mon occurrence of a rudiment of it in man has caused some speculation among anatomists about the function of the foramen in mammals and the reason for its disappearance in man. None of the functional explanations heretofore proposed seems very convincing to me. The purpose of this paper is to propose a new explanation for the function of this foramen and for its disappearance in mammals.

Acknowledgments.—My thanks are due to Dr. Clinton Conaway of the Zoology Department, University of Missouri for the use of a mounted skeleton and an embalmed specimen of *Felis*, and for permission to examine mounted skeletons of *Canis, Maccacus, Lemur, Didelphis, Phalanger,* and *Sus* in the possession of the Zoology Department. I am grateful also to Dr. William Elder of the Zoology Department, University of Missouri for the loan of the mammalian humeri depicted in Figure 1.

Finally, I would like to acknowledge the assistance of Mrs. Geneva S. Williams, who prepared the illustrations for this paper.

PREVIOUS EXPLANATIONS

The first explanation of the function of the entepicondylar foramen was that of Everhard Home (1814) who suggested that the en-

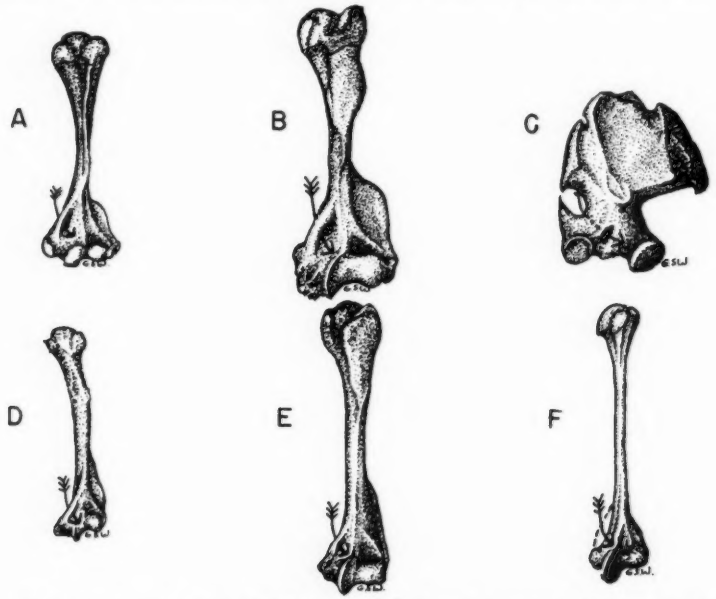


Fig. 1.—Anterior view of left humeri of various mammals showing entepicondylar foramina, all drawn the same size. A. *Didelphis virginiana;* B. *Taxidea taxus;* C. *Scalopus aquaticus;* D. *Sciurus niger;* E. *Procyon lotor;* F. *Homo sapiens* (showing position of supracondyloid process and ligament).

tepicondylar arch would protect the brachial artery at the elbow during contraction of the overlying flexor muscles. This explanation was early discarded by students of the entepicondylar foramen but the explanation got into Gray's Anatomy and may be found there today in the latest edition (26th Edition, 1954; 205).

Objections to Home's explanations were summed up by Ruge (1884). He pointed out that one would not expect to find the foramen missing in the Old World anthropoids who perform a variety of complex forearm movements. If the entepicondylar arch protects the underlying filiform structures during contraction of the forearm flexors, why should the arch usually be missing in precisely those forms that presumably would need it most? He also pointed out that the brachial artery does not always traverse the entepicondylar foramen when one exists.

To my mind, Home's notion is illogical because the ulnar artery, one of the two terminal branches of the brachial, is more intimately related to the flexor muscles than is the brachial and furthermore, is smaller than the brachial, yet the ulnar has no bony arch over it. Even if there is a high division of the brachial so that the ulnar artery instead of the brachial traverses the entepicondylar foramen, the objection holds because the bony protection is in the wrong place.

Tiedemann (1818a, 1818b) suggested that the entepicondylar arch might protect the artery and nerve from external blows or pressures. The nerve and artery, however, after leaving the protection of the arch enter the antecubital fossa, an even more exposed location.

Home's and Tiedemann's ideas were confused by Ruge (1884) and subsequent authors, who may attribute Home's idea to Tiedemann or assume that the two explanations are the same. It is a curious fact that Tiedemann, who had devised a functional explanation for the entepicondylar foramen, did not recognize the supracondyloid process in man as the homologue of the structure he had studied in other mammals only four years previously.

Meckel (1825) suggested that the entepicondylar arch had no protective function but that the presence or absence of an entepicondylar foramen depended upon the width of the distal end of the humerus. A humerus that was narrow at the distal end would lack an entepicondylar foramen, while a humerus that was wide at the distal end would have one. The median nerve and brachial artery running parallel to the shaft of the humerus would either have to pierce a wide medial epicondyle or swing out of line around it to reach the forearm. The more direct route would obviously be through the medial epicondyle.

In support of this theory Struthers (1881) pointed out that among the edentates the foramen is present in the anteaters, whose humeri are wide at the distal end and absent in the sloths, whose humeri are narrow. One may also cite in favor of this idea the fact that in ungulates and hystricomorph rodents, where the entepicondylar foramen is always absent, the distal ends of the humeri are narrow.

Stromer (1902) rejected Meckel's explanation. He pointed out that the humerus of the cat has an entepicondylar foramen even though this humerus is narrow at its distal end. I agree that this suggests that the foramen does have some function other than merely providing the most direct route for vessels and nerves to the forearm.

In general, it is true that humeri with broad distal ends have an entepicondylar foramen, but I do not think that the wide humerus is the cause of the foramen. Primitive mammals have humeri with wide distal ends and primitive mammals have entepicondylar foramina. Specialization of the humerus tends to remove both of these primitive features.

Gruber (1859) thought that the supracondyloid process in man was correlated with an anomalous development of the pronator teres muscle where this muscle takes origin from high up on the shaft of the humerus instead of from its usual origin on the entepicondyle. The pull of the muscle here would form a process (Fig. 1). Ruge (1884) pointed out that in carnivores where the entepicondylar fora-

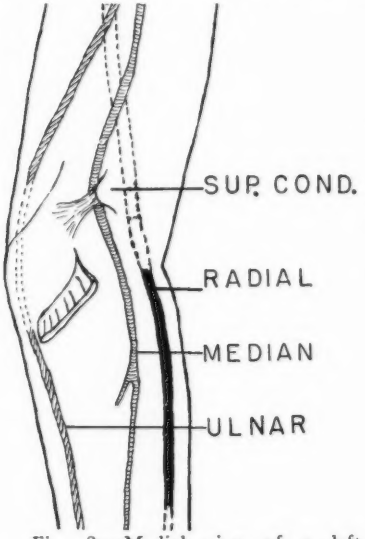


Fig. 2.—Medial view of a left human arm showing the supracondyloid process (sup. cond.) and ligament and their relationship to the median nerve. The superficial flexors have been removed. Modified after Huntington (1918).

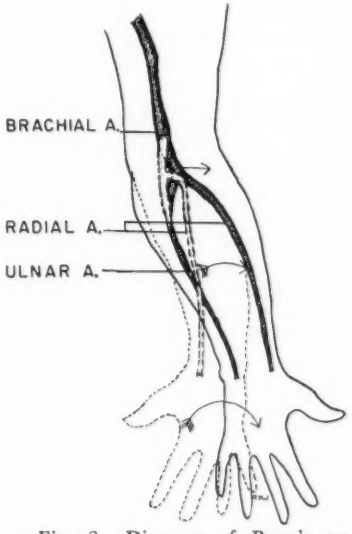


Fig. 3.—Diagram of Ruge's explanation of the disappearance of the entepicondylar foramen in man. The dotted lines show the positions of the forearm and the radial artery in the prone position. The solid lines show these structures in the supine position. Supination of the forearm pulls the brachial artery laterally (top arrow).

men is common, the pronator teres does not take origin from the entepicondylar arch. Ruge believed that the relationship suggested by Gruber was reversed, that actually the appearance of the process and its ligamentous continuation to the epicondyle provided an opportunity for the origin of the pronator teres to shift upwards onto the process.

Laugier (1933) pointed out that a high origin of the pronator teres in man is not necessarily correlated with a supracondyloid process. He cites at least one case where the pronator teres took origin from the intermuscular septum above the medial epicondyle. Indeed, Gruber (1859) described one such case but apparently did not consider it relevant. Laugier further states that he found the same high origin of the pronator teres from the intermuscular septum on one specimen each of chimpanzee and orang-outan. It is thus possible that the high origin of the pronator teres is a primate specialization, occurring as an anomaly in man, that is sometimes superimposed upon a supracondyloid process.

Lesshaft (in Struthers, 1881) suggested that the entepicondylar arch might act to reinforce the medial epicondyle against the thrust of the ulna. Stromer (1902) rejected this suggestion on the grounds that the entepicondylar arch is oriented in the wrong direction to act as an efficient brace. He also rejected the opposite hypothesis (whose origin he did not identify) that the entepicondylar arch acts to anchor the medial epicondyle against the pull of the hand flexor muscles, which take origin from there. He stated that the bony bar is too slim, relative to the thickness of the medial epicondyle, to appreciably strengthen it.

Ruge (1884) proposed that the entepicondylar arch arose through the influence of muscle attachment. The pull of some muscle that originated or inserted on the shaft of the humerus resulted in the building up of a bony process there. He believed that this occurred early in the history of mammalian evolution and that the muscle (or muscles) responsible for this development have long since shifted their attachments from the process in response to various adaptational needs. The entepicondylar arch in Ruge's opinion is thus a primitive heritage character that persists in mammals as long as no adaptation requires its removal.

The disappearance of the foramen in man, he explains as a consequence of the development of the ability to supinate the arm. When the forearm is supinated, the radial artery, following the radius, is moved laterally. This movement in turn pulls the brachial artery, of which the radial is a branch, laterally (Fig. 3). A brachial artery running through an entepicondylar foramen would thus be pulled against the entepicondylar arch. Ruge believed that the pulsating of the artery against the bone would result in the disappearance of the bony material and hence of the entepicondylar arch. Reduction of bone through the pressure of adjacent blood vessels certainly does oc-

cur, as for instance, in the elaborate sculpturing of the inside of the calvarium in mammals.

In further support of his argument Ruge cites the fact that in man, when the supracondyloid process does occur as an anomaly, the brachial artery commonly gives off a large collateral above the process, which shunts the bulk of the blood supply to the forearm down the middle of the arm so that a smaller vessel passes around the supracondyloid process and under the ligamentous arch. Ruge's description appears to be only another way of saying that the supracondyloid process is frequently correlated with a high division of the brachial artery, so that only the ulnar artery passes beneath the ligamentous arch (see Huntington, 1918, plate V).

Ruge's argument, to my mind, is more ingenious than convincing. It explains the loss of the entepicondylar foramen in the higher primates but not in other mammals. The entepicondylar foramen is typically lacking in ungulates among whom supination of the arm is impossible. Taking mammals as a whole, the more restricted the movements of the forearm the more likely is the entepicondylar foramen to be lacking. Ruge's argument, therefore, cannot be generalized to apply to all the Mammalia.

Even applied to man the argument is weak because it is too much influenced by the artificial convention of the "anatomical position". It is true that in extreme supination the brachial artery would tend to be pulled laterally, but actually, people do not often hold the hand and forearm in this position. The natural relaxed position of the hand is closer to the prone than the supine. Persons holding the hand in the extreme supine position over long periods of time are found chiefly in anatomy textbooks.

A further objection to Ruge's theory is that the supracondyloid process, when it does appear in man, appears at the site of the proximal end of the entepicondylar arch. This is the most lateral portion of the arch and should be the part most pressed against by the pulsating artery passing beneath, (Fig. 1 (F) and Fig. 2) and consequently the part most susceptible to disappearance. We should, therefore, seldom expect to find the proximal end of the entepicondylar arch as a remnant. If Ruge's explanation were correct, we should most often find the bony process on the entepicondyle, continued by a ligamentous band up to the shaft of the humerus. As far as I know, the supracondyloid process never assumes this form in man.

Stromer (1902) was the first to note that the disappearance of the entepicondylar foramen among mammals actually correlates with reduction in ability to supinate the arm. The foramen is most frequently lost in running forms (ungulates, dogs, hyaenas). He attributes the discovery of this correlation to Schlosser (1900) but I can find no reference to it in the work cited. Schlosser's paper contains a list of forms possessing the entepicondylar foramen but expresses no opinions on its function.

Huntington (1918) stated (p. 390) that ". . .the arrangement has a functional significance in the use of the anterior extremity, protecting the main brachial or ulno-interosseous artery of the limb and the brachial nerve, which pass through the foramen against undue pressure in forcible flexion of the forearm on the brachium at the elbow."

This explanation is unsatisfactory because it does not explain why running forms should lose the entepicondylar foramen. Surely an antelope is more likely to flex the forearm forcibly against the brachium than is an opossum. Furthermore, Huntington's theory would not explain the existence of the foramen in primitive reptiles whose humeri are abducted 90° from the mammalian position so that the distal limb segment is not flexed against the humerus in walking.

FUNCTION OF THE FORAMEN

All of these explanations (except the last) are primarily based upon consideration of the relationship of the brachial artery to the foramen without much regard for its relationship to the median nerve though the foramen is more constant than the passage of the brachial artery. The brachial artery does not always traverse the entepicondylar foramen (Gruber, 1858; Leche, 1906, Tafel XXVII *Lemur catta;* Struthers, 1881, *Herpestes ichneumon;* Müller, 1904, Procyonidae, *Lemur catta,* and *Phoca vitulina;*) but Gruber stated that he knew of no humerus with an entepicondylar foramen not penetrated by the median nerve and this statement has not been disputed. One would think *a priori* that the nerve would furnish a better lead to the function of the foramen than would the artery.

The function of the entepicondylar foramen becomes apparent upon consideration of the position of the forelimb of a primitive mammal.

In most mammals the forelimb in the resting, standing position is sharply bent at the elbow. The humerus points backward and distal limb segments reverse the direction to point forward once more so that the distal ends of the radius and ulna fall in roughly the same transverse plane as the proximal end of the humerus (Fig. 4). The observation is commonplace but its important consequence is that all the filiform structures (nerves, arteries and veins) supplying the distal limb segments must be held down against the bone at the elbow if the filiform structures are not to sag forward across the angle of the elbow when the animal is standing (Fig. 4).

In most mammals, in contrast to man, the skin and overlying muscle of the axilla are too loose to prevent this arching, for in most mammals the humerus is almost buried in the axilla. The pectoral muscles insert far down on the shaft and the skin covering the region is quite loose. The skin over the dorsal side of the axilla may run to the elbow (Fig. 4).

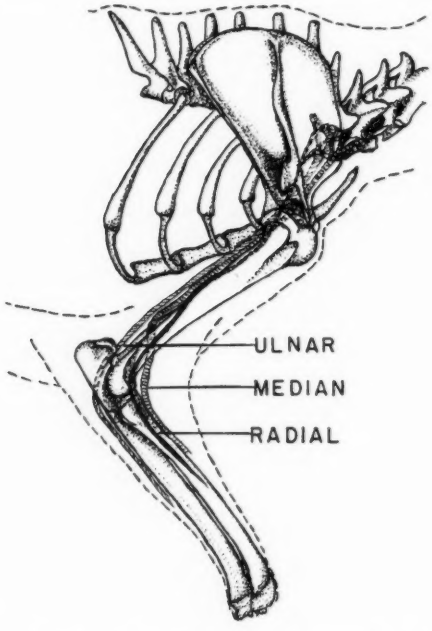
The entepicondylar foramen, then, is a retinaculum, which prevents the median nerve from cutting across the angle of the elbow. If this explanation is correct, we must explain why only the median

nerve and sometimes the brachial artery of all the filiform structures of the arm require this retention.

The vascular structures give off branches to muscles and bones throughout the forelimb, and also form complex anastomoses around the elbow. These branches and anastomotic collaterals serve to anchor the vessels firmly around the elbow.

The radial nerve gives off branches in the upper arm and spirals around the shaft of the humerus from the medial to lateral side, deep to the medial head of the triceps. The nerve does emerge from beneath the muscle mass to cross the anticubital fossa, but immediately upon reaching the upper end of the forearm the radial nerve gives off its deep, or posterior interosseous branch, which firmly ties the nerve to the elbow.

The ulnar nerve runs down the medial side of the upper arm, without giving off any branches, but near the distal end of the hu-



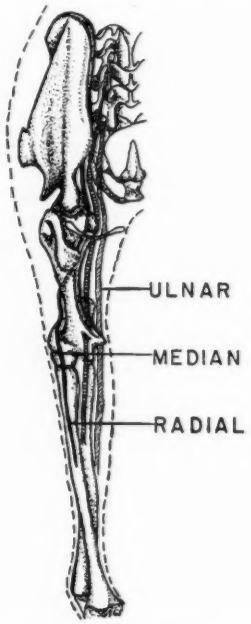


Fig. 4.—(*left*). Skeleton and nerves of the forelimb of a cat, lateral view. The ulnar nerve has been displaced caudally and the radial nerve medially to bring them into view. The dashed lines show the outlines of the covering skin and muscle. Note the great depth of the axilla compared to the human condition. Fig. 5—(*right*). Skeleton and nerves of the forelimb of a cat, cranial view. Note the passage of the radial and ulnar nerves behind the humerus and the passage of the median nerve through the entepicondylar foramen.

merus, the nerve pierces the medial intermuscular septum and curves under the medial epicondyle to enter the ventral, flexor muscle mass. It is thus impossible for the ulnar nerve to stretch across the elbow (Figs. 4 and 5).

The median nerve, however, if it were not held back by the entepicondylar arch, would be free to sag forward across the angle of the elbow (Figs. 4 and 5). The median nerve gives off no branches in the upper arm and lies along the medial side of the biceps. The biceps does not hold down the nerve except at the upper end of the radius and ulna, where the bicipital aponeurosis crosses the nerve. The pectoral muscles do not cover the distal-most part of the humerus and are not oriented in the right direction to keep the median nerve down against the humerus along most of its length. If the entepicondylar arch did not hold back the nerve, it would be free to stand out from the elbow beyond the caudal edge of the pectorals, covered only by loose skin and the thin epitrochlearis muscle.

The passage of the brachial artery through the foramen is fortuitous. The nerve and artery develop side by side so that a structure enclosing one would automatically enclose the other. The artery is bound down around the elbow by its anastomoses and needs no other retention. This explains why the artery sometimes does not traverse the foramen, whereas, so far as I know, whenever a foramen exists the median nerve passes through it.

If the entepicondylar foramen is so useful to mammals one must explain why so many of them have lost it. Stromer's (1902) observation that the absence of the foramen correlates in general with loss of ability to supinate the forearm is valid, but I think that loss of supination is in turn correlated with loss of ability to abduct the humerus. One of the important limb adaptations of running animals is restriction of the limbs to movement in the cranio-caudal plane, a restriction that means loss of both supination and abduction in the forelimb. The loss of abduction is responsible for the loss of the entepicondylar foramen. When the limb is in the normal standing position, the medial side of the elbow is well protected, since it is pressed against the animal's side and is well back from the cranial end of the chest. When the arm is abducted the median nerve is exposed to blows or pressures. The worst possible combination of movements would be abduction of the humerus and extension of the forearm, as a cat does in cuffing with its forepaw. This motion takes the medial side of the elbow away from the side of the body and brings it forward. If the medial nerve were not held back out of the way it might slump forward to a vulnerable position.

An indication that the entepicondylar foramen is correlated with abduction is the fact that the foramen is present in moles. As noted above, the entepicondylar foramen is present in primitive humeri and absent in specialized ones. How is it then that the foramen is present in the humeri of moles (Fig. 1 (C)), the most extremely adapted humeri to be found in mammals? The answer, it seems to me, is that

moles normally carry the humerus in extreme abduction (Reed, 1951) and thus need a retinaculum for the median nerve.

The loss of the entepicondylar foramen in anthropoids, however, cannot be attributed to loss of the ability to abduct the arm since it is among the anthropoids that abductability reaches an extreme. Paradoxically, it is precisely this development of extreme abduction that is responsible for the loss of the entepicondylar foramen in that group. The axilla has been shortened in anthropoids in order to permit the great freedom of arm movements possible in those animals. The pectoral muscles cover only a small portion of the shaft of the humerus near the head and the distal end of the humerus is covered, not with loose baggy skin and thin muscles, but with a tightly adherent skin and deep fascia that effectually prevent the nerve from arching across the elbow under any conditions. The entepicondylar foramen thus becomes unnecessary, but the foramen is not disadvantageous and may be retained as in the New World monkeys or *Cercopithecus* (Giebel, 1879; Stromer, 1902).

Considering the entepicondylar foramen a retinaculum for the median nerve does not explain how the foramen can be absent in one species and present in a closely related one, a common situation in rodents, for example. The explanation of these differences may be found in differences between the natural histories of the animals. A pugnacious species might have to have the median nerve fixed at the elbow to insure that the nerve was held back out of the way while fighting. A less aggressive congener might not require this development. An arboreal species might have more occasion to abduct the humerus than a ground dwelling species and might therefore have greater need for tying down the median nerve at the elbow. Even though two species were anatomically able to abduct the humerus to the same extent, the fact that one of them habitually did so more than the other might mean that the entepicondylar foramen would be selectively advantageous in the first and not in the second.

Finally, the absence of the entepicondylar foramen in a species may be illusory. I have sometimes found the entepicondylar arch in rodents represented by a thin bony bar and sometimes only by a bony spur projecting from the humerus continued by a ligamentous band down to the medial epicondyle (as in man). I counted such a humerus as lacking an entepicondylar foramen, but one is functually present. I have found these ligamentous arches as exceptional conditions in species where the arch normally occurs, but it is entirely possible that the arch is normally represented by a ligamentous band in some species. A ligamentous retinaculum would be just as effective as a bony one but it might not be detected on cleaned skeletons.

The above explanation may account for the presence of an entepicondylar foramen in mammals but does it explain the origin and retention of the foramen in reptiles? Certainly the humerus of primitive reptiles was not buried in the axilla, for the humerus was abducted to 90° from the mammalian position. I have not dissected reptile limbs

and I am not familiar with the exact relationship of structures therein, but I would think *a priori* that a bony retinaculum at the elbow for filiform structures would be advantageous in a limb that stands out laterally from the body wall.

As a matter of fact there were two of these retinacula in early reptiles, the entepicondylar foramen on the caudal side of the humerus (medial in mammals) for the median nerve, and an ectepicondylar foramen on the cranial side of the limb (lateral in mammals) for the passage of the radial nerve.

The ectepicondylar foramen has disappeared in mammals presumably in correlation with the shift of the distal end of the humerus under the body (see Romer 1945) and change in position of the origins and the extensors of the hand which involved a shift in the course of the radial nerve. I must admit that the absence of the ectepicondylar foramen in monotremes, who retain the primitive reptilian forelimb position argues against this, but the loss may be due to some specialization of monotreme limbs. Clarification of this matter awaits the attention of some competent reptile anatomist.

SUMMARY

The entepicondylar foramen or supracondyloid foramen is a canal through the distal end of the humerus of mammals for the passage of the median nerve and brachial artery. Neither the function of this structure, where it exists, nor the reason for its disappearance, where it does not exist, have ever been satisfactorily explained.

Theories of the function of the entepicondylar foramen may be divided into three types: (1) theories proposing that the foramen protects the traversing structures; (2) theories proposing that the presence or absence of the foramen depends upon the shape of the distal end of the humerus; and (3) theories proposing that the bony arch of the foramen acts as a brace or strut.

This paper rejects all of these theories and proposes that the entepicondylar foramen in quadrupeds acts as a retinaculum for the median nerve, to prevent it from slumping across the angle of the elbow. In quadrupeds, the axilla is deep, enclosing most of the humerus, so that the skin over the elbow is loose and does not hold down the nerve.

The median nerve is the only filiform structure of the arm requiring this retention. The vessels give off numerous branches, while the radial and ulnar nerves pass behind the humerus before entering the forearm.

Cursorial and ungulate mammals have lost the entepicondylar foramen because they do not abduct the humerus and thus do not expose the median nerve.

Anthropoid primates (including man) have lost the foramen because their humeri have become highly abductible. The axilla has become greatly shortened and the skin fits tightly over the elbow, effectively restraining the median nerve.

REFERENCES

BAUR, G. 1887—Über die Kanäle im Humerus der Amnioten. Morph. Jahrb. 12:299-305.

COITIER, V. 1573—Externarum et internarum principalium humani corporis partium tabulae atque anatomicae exercitones observationesque variae. Norimb. [*Fide* Gruber]

GIEBEL, C. G. 1879—Osteologie, in Bronn, Klassen and Ordnungen des Thierreichs. Band 6, Abtheilung V. (Säugetiere). Nos. 21-75:417-544.

GOSS, C. M., ed. 1954—*Gray's Anatomy of the Human Body*. 26th Ed. Lea and Febiger, Philadelphia.

GRUBER, W. 1859—Monographie des Canalis supracondyloideus humeri und der Processus supracondyloidei humeri et femoris der Säugetiere und des Menschen. Mém. Sav. Étrang. (Mém. présenté à l'acad. Imp. Sci. St. Pétersbourg) 8:51-128.

HOME, E. 1814—Lectures on comparative anatomy. Vol. 1. London. [*Fide* Gruber]

HUNTINGTON, G. S. 1918—Modern principles of evolution, variation and inheritance in the anatomical part of the medical curriculum. Anat. Rec. 14:356-446.

KNOX, R. 1841—On the presence of a supracondyloid process in the human humerus. Edinburgh Med. and Surg. J. 56:125 [*Fide* Gruber]

LAUGIER, P. 1933—Le rond pronateur et ses rapports avec le foramen supracondyloideum. Étude d'anatomie comparée. Arch. d'anat., d'histol., et d'embryol. de Strasbourg 16:93-134.

LECHE, W. 1906—Das Gefässsystem, in Bronn, Klassen and Ordnungen des Theirreichs. Band 6, Abt. V (Säugetiere) (61-75):1170-1330.

MECKEL, J. F. 1825—System der vergleichenden Anatomie. Band 2, Abt. II. Leipzig. [*Fide* Gruber]

MUELLER, E. 1904—Beiträge zur Morphologie des Gefässsystems II Die Armarterien der Säugetiere. Anat. Hefte 27:71-242.

OTTO, A. 1839—De rariorbus quisbusdam Sceleti humani cum animalum sceleto analogis, Art. De canalis supracondyloidei ossis humeri in homine vestigo. Vratislavie. [*Fide* Gruber]

REED, C. A. 1951—Locomotion and appendicular anatomy in three soricoid insectivores. Am. Mid. Nat. 43:513-671.

ROMER, A. S. 1945—Vertebrate paleontology. Univ. Chicago Press, Chicago. 687 pp.

RUGE, G. 1884—Beiträge zur Gefässlehre des Menschen. Morph. Jahrb. 9:329-388.

SCHLOSSER, M. 1900—Über die Modifikationen des Extremitätenskelets bei den einzelnen Säugetierestämmen I. Die Vorderextremität. Biol. Centralbl. 9:684-698.

STROMER, E. 1902—Über die Bedeutung des Foramen entepicondyloideum und des Trochanter tertius der Säugethiere. Morph. Jahrb. 29:553-562.

STRUTHERS, J. 1881—On the processus supracondyloideus of man. Trans. Internat. Med. Congr. 1:148-151.

TIEDEMANN, F. 1818a—Meckels Deutsches Arch. Physiol. 4:548. [*Fide* Gruber]

———1818b—Meckels Deutsches Arch. Physiol. 5:349. [*Fide* Gruber]

———1822—Tabulae arteriarum corporis humani. Carlsruhae. [*Fide* Gruber]

Biology of the Oligochaete Eisenia rosea (Savigny) in an Upland Forest Soil of Southern Michigan

WILLIAM R. MURCHIE
University of Michigan, Flint College

For over 50 years, the contribution of Charles Darwin (1881) relating to the natural history of earthworms remained a foundation and point of departure for studies on field populations of earthworms. With the introduction of more modern methods of habitat analysis, particularly physico-chemical factors, and the development of statistical tools for population studies, there has been a renewal of investigative effort on the biology of the Oligochaeta. Despite the amount of information recently accumulated, however, the role of earthworms in forest soils is poorly understood. In part, this may be attributed to the fact that a large proportion of the research has been related to agricultural problems and to oligochaete populations in pasture and crop soils. Such investigations, their objectives, methods, and results, are often of limited applicability to forest conditions. Moreover, the complexity of forest soils and the difficulty of simulating field conditions in laboratory cultures impose restrictions on experimentation and limit the degree to which field data may be successfully interpreted.

The research reported here had two basic objectives: (1) to determine the effect of soil factors, especially moisture, upon qualitative and quantitative variation in an earthworm population, and (2) to study cyclic phenomena of field populations, i.e., determination of cyclic activities caused by inherent physiological rhythms as contrasted with cyclical behavior imposed by seasonal and climatological changes. Special attention was given to the species *Eisenia rosea* (Savigny) [= *Allolobophora rosea* (Savigny) of some authors]. No previous work pertaining to the ecology of this species, on an extensive scale, has hitherto been accomplished in North America. Murchie (1956) reported *E. rosea* as a common earthworm in Michigan; it is widely distributed throughout the northern hemisphere, inhabiting, in general, stream bank soils, compost heaps, and better upland soils. Identification of the oligochaetes collected during the course of this study was based upon the species descriptions presented by Frank Smith (1917).

Description of the Area

The woodlot chosen for this study included a 40-acre plot of mature oak-hickory, located in the east-central portion of Section 26, Ann Arbor Township, Washtenaw County, Michigan. For detailed investigation, an area near the center of this woods was selected, including portions of two low ridges and an intervening valley (Fig. 1).

Except for immature alluvial soils along major streams, the soils

of Washtenaw County are all of glacial origin. In the research area, the soils belonged to the Miami Series, of loam texture with light to moderate leaf litter. The soil was of mull type development with a very thin decomposition zone.

Vegetation of the study area consisted of oak, hickory, elm, ash, and red maple. Large trees, those with trunk diameters of from 12 to 16 inches were largely oaks; other species did not exceed 10 inches in diameter and were fewer in number. Saplings with trunk diameters up to two inches were quite common. *Rubus allegheniensis* Porter and *Viburnum acerifolium* L. occurred as local stands. The herbaceous growth was variable and will be described later.

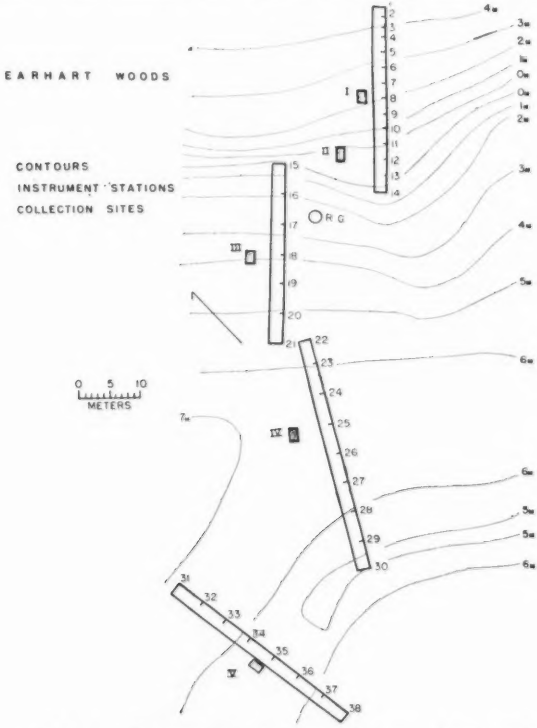


Fig. 1.—Diagram of the research area showing the relationships of instrument stations, collection sites in transect plots, and contour intervals. Roman numerals (I-V) denote instrument stations, shown as shaded rectangles. Arabic numerals (1-38) indicate collection sites in transect plots. Contour intervals indicate elevation in meters above floor of eastern valley. Circle (R.G.) shows position of rain gauge.

Drainage throughout that part of the woodlot under investigation was generally good. A series of seepage zones in a section to the west of the study area provided a moisture supply which drained freely through the eastern valley (Fig. 1, Station II) and into the area surrounding Station V. In both instances, flow was intermittent, being confined to the spring and late fall months. A high, woven wire fence surrounded the woods completely, and no grazing had ever been permitted insofar as I was able to determine. There had been no extensive cutting for 30 years at least.

METHODS

Determinations were made on pH, water holding capacity, organic carbon, and mechanical analysis for sand, silt, and clay. The Beckman potentiometric meter with a glass electrode was employed for pH, using a soil-water ratio of one-to-one by volume. For water holding capacity, I used Hilgard soil cups, reporting the results as percent dry weight of soil. A wet combustion method (Piper, 1947) was used for organic carbon. Readings were taken on a Klett-Somerson colorimeter with a red filter in the 760 mu range; results are reported in percent organic carbon based on dry weight of soil. I utilized the Bouyoucos hydrometer method for mechanical analysis; data on relative amounts of sand, silt, and clay are given as percent dry weight of soil.

TEMPERATURE

For instantaneous temperatures, thermistors were buried at depths of 5 and 20 cm. These units were constructed according to the method of Pruitt (1952), readings being taken with a modified Wheatstone bridge adapted for field use. In addition, Six-type, maximum-minimum thermometers were used. For soil temperatures, I housed these in small wooden boxes barely large enough to accommodate the instrument, but long enough so that the sensitive element was 35 cm from the door. Units were buried in such a way that the thermometer bulb was six cm below the soil surface. Once placed, the thermometers were never completely removed from the boxes until the investigation was completed.

For maximum-minimum air temperatures, thermometers were mounted in small shelters, open to the north, with the sensitive bulb 35 cm from the ground. All temperatures are reported (Fig. 2-A) in degrees Centigrade.

MOISTURE

The moisture unit employed in the investigation was the nylon element described by Bouyoucos (1949). This unit is formed of two metal grids separated by several folds of nylon cloth. Electrical resistance between the grids is dependent upon the amount of moisture present in the fabric. Inasmuch as the interstices of the nylon tend to

exert a "pull" on the soil water, the amount of moisture in the cloth is related to that present in the soil.

Elements were placed at depths of 5 and 20 cm. Readings in ohms of resistance were made by means of a Wheatstone bridge. The units were calibrated for the soil where they were located and the results are reported (Fig. 3) as total moisture in percentage, based upon dry weight of soil.

COLLECTION METHODS

Quantitative methods of sampling had to be devised for this study which would permit the activities and disposition of the organisms within the soil mass to be studied. The method decided upon involved examination of a soil sample 50 cm^3. A plot of such size afforded some means of observing the activities of worms as well as their distribution. Smaller samples would have been less tedious to search, but offered difficulty in penetration to lower depths while maintaining the integrity of the original surface area.

Before initiating a sampling program, I examined chemical methods such as those used by Evans and Guild (1947). These workers employed a solution containing one-quarter ounce of potassium permanganate per gallon of water. This vermifuge is added to the soil surface and under certain circumstances will bring the earthworms to the surface. I found that "wet-sampling" methods of this type were inoperable under the following conditions: (1) when the soil was wet, (2) during very cold or droughty periods when the worms were deep in the soil or in an inactive condition, and (3) in heavy clay soils. Because one of the primary objectives was to determine the activities of worms during adverse conditions, chemical methods were considered to have serious limitations.

Accordingly, specimens were dug by hand from the prescribed volume of soil. The latter was examined carefully to determine the position of the worms and their activities. Use of a screen was not feasible because worms in an inactive state are often reactivated if subjected to mechanical stimulation.

FIELD PROCEDURES

Extensive field studies and collections were made throughout the woodlot during spring, fall, and winter months of 1951 in order to determine the general nature and distribution of the oligochaete fauna. In all, six species of earthworms were found: *Allolobophora caliginosa* (Savigny), *Eisenia rosea* (Savigny), *Lumbricus terrestris* Linnaeus, *Lumbricus rubellus* Hoffmeister, *Octolasium lacteum* (Örley), and *Bimastos tenuis* (Eisen.) *Lumbricus terrestris, A. caliginosa,* and *E. rosea* were the only species collected on the area selected for study. Considerable qualitative and quantitative variation was found in the several parts of that area, and, in addition, certain seasonal changes in the population were evident.

During the month of March 1952, four transect plots were established (Fig. 1, 1-38). These were arranged so as to approach each slope directly, providing thereby the greatest possible change in exposure, drainage, and elevation within the shortest linear distance. Five instrument stations were placed adjacent to the transect plots (Fig. 1, I-V). The area surrounding Station V was selected for detailed study of seasonal population activity.

From May 1 until September 15, 1952, readings of moisture and temperature were taken every other day. Beginning in mid-September, 1952, and until the end of the field work in June, 1953, readings were made every third day. The stations were visited between 10 a.m. and 2 p.m. Seasonal activity was observed through bi-weekly collections made in the area near Station V from April 15, 1952, through June 6, 1953. Only one collection was made in December, 1952.

I collected soil samples and earthworms from the transect plots during a four-day period from April 19 to April 22, 1953. It was desirable that the period be kept brief in order to avoid variations in soil conditions due to weather changes. Three earthworm samples and a composite soil sample were removed from each of the instrument station plots on May 6 and 7, 1953. At the same time, a plant census was taken of a square meter area on each station plot. On June 10, 1953, I removed all instrument units along with soil for the purpose of calibrating the Bouyoucos elements.

Description of Stations

Each instrument station consisted of thermistors and moisture units buried at 5 and 20 cm in the center of a plot 2 m^2. Instrument terminals and maximum-minimum thermometers were kept at the edge of each plot so that the soil and vegetation were not disturbed after installation of the units.

Stations I and III were located on south- and northeast-facing slopes respectively. Station IV was near the crest of the central ridge. Soil conditions were, in general, similar at I, III, and IV; the dark humus soil layer was about 5 cm in depth, and below this the soil became yellow-gray loam, extending approximately 25 cm. Deeper soil layers were gritty, sandy clay with numerous pebbles and some small boulders.

Stations II and V differed markedly from the others; in both instances, a deep humus layer with good crumb structure, lay over a base of yellow clay-loam. In depth, the humus layer of Station II extended 75 cm whereas that of Station V ended at about 20 cm.

Field Data

Temperature

Instantaneous temperature readings and maximum-minimum records revealed no essential differences between station plots. Thus, the maximum-minimum records for air and soil as obtained at Sta-

tion III are presented (Fig. 2 A). These data are representative of temperature conditions prevailing in the woodlot from May, 1952 through April, 1953.

In the winter preceding instrumentation, the soil near Station III froze to a depth of eight inches in early February and remained frozen until late March. Except for a slight crust of frost-bearing soil which formed a few times during the winter of 1952-53, general soil freezing was not encountered within the research area. The maximum soil temperature recorded was 23 degrees Centigrade.

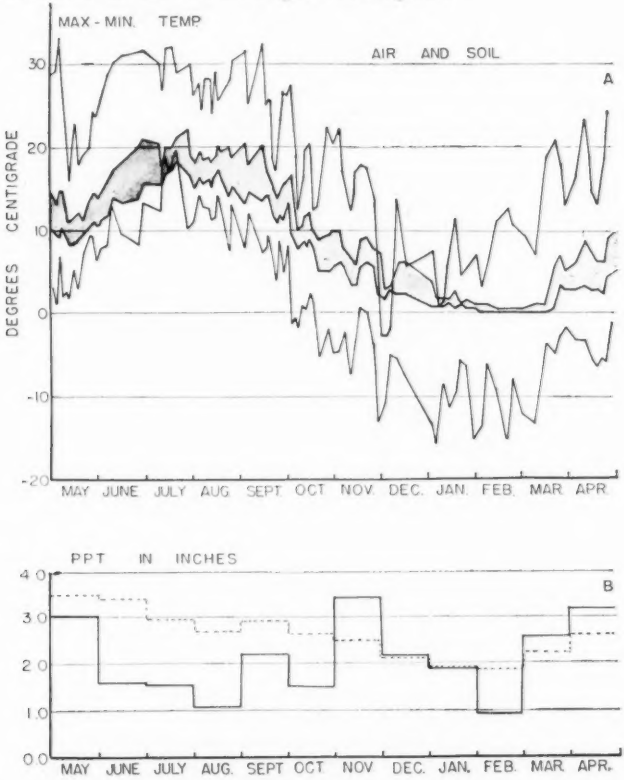


Fig. 2 A.—Temperatures for air and soil in the woodlot from May 1, 1952 through April 30, 1953. Upper and lower limits of shaded area denote maximum and minimum soil temperatures. Outer lines represent maximum-minimum air temperatures. 2 B.—Monthly precipitation averages and a 50-year summary of monthly averages obtained from the United States Weather Bureau Station on the University of Michigan Campus from May 1, 1952 through April 30, 1953. The solid line represents the monthly averages; the dotted line indicates the 50-year averages.

MOISTURE

Figure 2 B presents monthly precipitation averages; and a 50-year summary of averages as obtained by the Ann Arbor Station of the United States Weather Bureau. From June 1 through October, 1952, rainfall occurred six times; all rainfall recorded for October fell during a single day. Pronounced wilting of herbaceous growth was evident throughout the woods in August and September. In the summer period, drought conditions were recorded for all stations (Fig. 3); this was changed only by temporary recovery at five centimeter depths

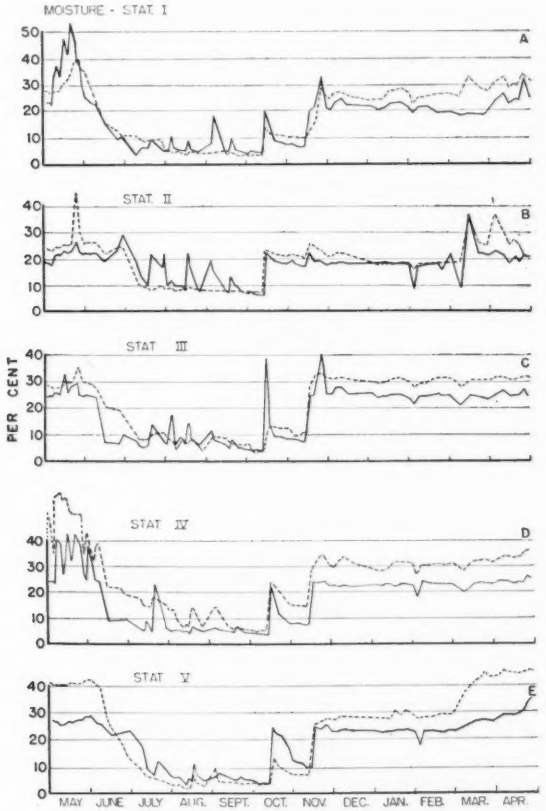


Fig. 3.—Total available moisture reported in percent dry weight of soil; determined by means of nylon resistance units at Stations I through V, from May 1, 1953 through April 30, 1953. Solid lines represent moisture at 5 cm depth; dotted lines, at 20 cm depth.

following showers. Except for depressions in the moisture level due to slight freezing at the soil surface, moisture content remained near the point of field capacity during the later fall, winter, and spring months. Thus, from the standpoint of moisture, two distinct "seasons" prevailed in the research area.

A comparison of the data for soil moisture (Fig. 3, A-E) shows strong resemblance between Stations I, III, and IV. Station II was characterized by the briefest "dry" period and Station V by a marked increase in moisture content of the soil during late March, April, May, and early June. It is clear that the moisture regime is best described on the basis of the deeper soil, in this case, the 20 cm level.

Interpretation of these data requires consideration of: (1) the length of the "dry" season, and (2) the total moisture level maintained by the soil. It is obvious that both of these factors in soil moisture content will exert a tremendous influence on the behavioral pattern of earthworms.

HERBACEOUS VEGETATION

Although tree cover was uniform throughout the research area, ground cover varied considerably. One-meter-square plots were examined at each instrument station on May 5, 1953. In all, 28 species of herbaceous plants were found: 13 on Station I, 16 on Station II, 14 on Station III, 14 on Station IV, and 3 on Station V. Counts of individual plants were: 126, 144, 97, 94, and 15 for Stations I-V respectively.

PHYSICO-CHEMICAL ANALYSES AND EARTHWORM COUNTS

During a four-day period (April 19 to April 23, 1953) the writer collected 38 samples for soil analyses and earthworm counts. These samples were spaced along four transects (Fig. 1) arranged so as to provide the greatest change in soil conditions in the shortest distance. Previous to this (May 6 and 7, 1953), three earthworm samples and a composite soil sample were taken from each instrument station plot. Comparison of Tables I, II, and III will show that similar conditions prevailed at instrument station levels equivalent to collection sites in the transect plots.

Even cursory examination of the results obtained from these 53 quarter-meter samples, reveals the extreme discontinuity in the distribution of *Eisenia rosea* throughout the research area. The near absence of worms along the eastern ridge (collection sites 3 through 10) and at sites 15 through 17, is noteworthy. On the other hand, a general homogeneity of measured physico-chemical factors throughout the entire transect appears to afford no basis for designating them as the cause of this highly variable distributional pattern. Considering only the earthworm counts and physico-chemical data of the transects, correlation coefficients for pH, water retaining capacity, organic carbon, and mechanical analysis for clay, were determined to be 0.133,

TABLE I.—Summary of physico-chemical analyses and counts of earthworms from collection sites in transect plots. Sites 1-14 were sampled at two and one-half meter intervals; subsequent samples at five meter intervals. Horizontal lines separate the collection sites into their respective transects. The asterisk (*) indicates an instrument station is adjacent to this collection site.

Collection site number	pH	Percent organic carbon	Percent water retaining capacity	Percent sand	Percent silt	Percent clay	*Allolobophora caliginosa*	*Lumbricus terrestris*	*Eisenia rosea*
1	6.25	0.720	64.4	57.0	32.6	10.4	11	3	0
2	5.8	0.615	65.6	52.5	34.9	12.6	4	3	0
3	5.3	0.615	78.0	54.2	34.0	11.8	0	0	0
4	6.0	0.630	68.3	53.6	34.6	11.8	0	0	0
5	6.2	0.630	63.8	46.8	42.0	11.2	1	2	0
6	6.1	0.670	64.5	46.0	44.0	10.0	0	0	0
7	5.5	0.585	56.9	54.5	36.9	8.6	0	0	0
*8	5.5	0.690	70.8	54.2	35.0	10.8	2	1	0
9	6.4	0.450	57.3	58.2	32.9	8.9	0	1	0
10	5.5	0.555	64.0	59.6	30.8	9.6	2	0	1
11	6.4	0.585	85.0	51.4	33.1	15.5	0	5	1
*12	6.8	0.615	81.3	55.2	22.0	22.8	6	4	0
13	6.9	0.660	82.2	55.5	29.9	14.6	2	7	1
14	6.4	0.690	73.5	52.2	36.0	12.8	0	2	5
15	6.4	0.615	63.4	55.2	35.0	9.8	0	1	0
16	7.2	0.600	68.0	60.8	31.0	8.2	0	0	0
17	5.8	0.60	77.0	48.0	42.0	10.0	0	0	0
*18	5.8	0.540	60.0	53.0	35.0	12.0	7	1	1
19	5.7	0.615	69.0	48.6	39.0	12.4	5	1	1
20	5.1	0.510	65.0	48.0	38.0	14.0	6	1	0
21	5.8	0.705	71.0	50.6	36.0	13.4	18	3	2
22	5.9	0.645	68.6	51.2	40.8	8.8	16	0	0
23	5.8	0.570	61.3	47.9	37.9	14.2	10	3	0
24	6.1	0.675	65.8	44.8	38.0	17.2	15	5	0
*25	4.3	0.705	73.5	49.2	35.0	15.8	7	0	0
26	5.1	0.645	76.0	48.8	36.0	15.2	2	2	0
27	6.7	0.630	73.0	49.6	38.0	12.4	12	5	0
28	4.5	0.285	57.0	47.6	38.0	14.4	9	2	0
29	5.0	0.510	66.3	59.2	30.0	10.8	7	3	0
30	5.8	0.585	72.4	43.2	35.0	21.8	26	5	2
31	6.0	0.480	62.4	46.8	38.0	15.2	9	3	4
32	5.4	0.690	66.0	46.2	41.0	12.8	3	5	0
33	5.1	0.480	56.0	50.0	40.0	10.0	11	2	0
34	5.8	0.615	71.0	49.0	38.0	13.0	19	10	24
*35	5.8	0.675	96.0	41.6	34.0	24.4	3	1	24
36	5.6	0.615	77.9	43.8	37.0	19.0	6	1	3
37	5.8	0.630	72.0	50.0	34.0	16.0	11	2	11
38	6.5	0.720	62.0	42.2	39.0	18.8	6	1	8

0.133, 0.212, 0.113, and 0.511 respectively. None of these may be considered a significant value.

DISCUSSION

A number of theories have been advanced to explain variations in population density of earthworms which may occur in adjacent soil masses. The factors often considered as responsible for these variations may be classified into three major categories: (1) physico-chemical (temperature, moisture, pH, inorganic salts, aeration, soil texture), (2) available food (herbage, leaf litter, consolidated organic material), and (3) reproductive potential and dispersive powers of the species. A majority of investigators have properly concluded that no single factor is likely to be responsible for numerical differences, but rather the interaction of several soil conditions. In general, the data presented here bear out that contention.

With regard to pH, Bodenheimer (1933) has pointed out that extreme values may be limiting, but, as the hydrogen ion concentration approaches neutrality, it loses its limiting influence. It is apparent that, although the soil pH in the woodlot under investigation was probably not optimal, it certainly could not be considered a limiting factor. This may be said as well for the results obtained on organic carbon, water retaining capacity, and mechanical analysis; that is, none of these is available to explain the observed population differences of *Eisenia rosea* reported here. Similarly, temperature differences between stations were negligible.

The apparent lack of correlation between soil factors and population density has been a basic problem in earthworm ecology. Guild (1952) has stated:

> "Where enumeration data are obtained from an environment which is affected by many factors, some of which cannot be expressed numerically, e.g., factors comprising a soil environment, it is always difficult and risky to make strict interpretation of figures obtained from statistical analysis of the data."

In the same paper, Guild (1952) has demonstrated that numerical differences occurring in normal populations of earthworms within small areas are often greater than those which might be expected from random sampling in a uniform population. With respect to this problem, Satchell (1955) has written:

> "Aggregations also occur, however, in situations where the habitat seems to be very uniform and, although this may be a reflection of our ignorance of what factors really affect earthworm distribution, nevertheless much of the irregularity of distribution may be related more to changes in the population's vital coefficients than to spatial variations in the environment."

It is probable that some of the variation in population density found in sections of the research area could be attributed to these "vital coefficients" (reproduction and dispersion), as well as to historical conditions. The latter would include predation or a temporary concentration of reproducing individuals occurring when especially favorable conditions prevail for a season or two. I cannot, however,

TABLE II.—Results of Physico-Chemical Analyses on Soils of Stations I-V.

In each instance, the soils were collected from the same depth at which the moisture and temperature units were located.

Station	Depth in Centimeters	pH	Percent Water Holding Capacity	Percent Organic Carbon	Percent Sand	Percent Silt	Percent Clay
I	5	5.1	51.0	0.480	52.8	38.0	9.2
	20	5.2	29.1	0.150	52.8	33.5	13.7
II	5	6.4	60.4	0.555	61.78	22.7	15.52
	20	6.3	68.2	0.555	56.5	27.07	16.43
III	5	5.3	64.0	0.600	53.4	36.08	10.52
	20	5.0	34.6	0.225	50.2	26.0	23.8
IV	5	5.7	49.0	0.645	49.0	39.07	11.93
	20	4.7	40.2	0.090	43.0	26.0	31.0
V	5	5.8	66.2	0.660	51.0	31.6	18.4
	20	5.62	38.2	0.270	50.2	28.0	21.8

draw upon such "vital coefficients" to explain the almost complete absence of *Eisenia rosea* through much of the woods, nor can this explanation suffice for the marked increase in numbers shown for the area surrounding Station V. This does not mean that the interpretation of the relationship between earthworms and their environment must always rely on subjective judgment; certainly, statistical models and laboratory experimentation will remain powerful tools in ecological studies. Extrapolation into field situations, however, insofar as earthworms are concerned, must consider as much of the total biology of the species and as complete an analysis of the habitat as can be comprehended. To give an example of the problems involved, soil freezing might be designated as a cause of earthworm mortality when, (1) the soil freezes, (2) earthworms are fewer in number where soil freezes, and (3) statistical analysis affords a basis for confidence in this conclusion. The latter, however, can scarcely be justified if sampling methods do not take into account the movement of the population into a position where they are not adequately sampled by the methods employed.

The soil conditions of this woodlot were not, in general, optimal for earthworms and were especially restrictive along the sides of the eastern valley. Although other factors remained fairly constant, soil moisture became more stable along the ridge (Table I, collection sites 18-38) and was most suitable in the vicinity of Station V (collection sites 34-38), thus permitting the species *Eisenia rosea* to flourish.

The substantial increase in colloidal content of the soil, as indicated by its clay content, was probably of importance in the retention of some of this moisture. Site quality based upon a measurement of this factor cannot, however, be used as an index of habitat suitability for earthworms without considering the prevailing drainage conditions. This, in turn, requires data on seasonal fluctuation. Determinations made at the time of earthworm sampling only (Olson, 1928; Grant, 1956) are of limited value unless one can be certain that no considerable change will take place in ensuing seasons.

The writer is convinced that drainage and soil moisture are to be considered as of paramount importance in earthworm distribution; other aspects of the soil environment become limiting only as they singly, or in combination with other factors, become extreme.

SEASONAL ACTIVITIES OF *Eisenia rosea*

As part of the research program in the Michigan woodlot, biweekly collections were made from a population of *Eisenia rosea* in the vicinity of Station V. Associated earthworm species represented here were *Allolobophora caliginosa* and *Lumbricus terrestris*. Two collections were made each month from April 15, 1952 through June 6, 1953, except for December, 1952, when only one sample was taken. These samples included a mass of soil 50 centimeters square and 50 centimeters deep. Field observations were made on the activities of

TABLE III.—Earthworm census of Stations I-V. Three samples were collected at each station.

Station	Species	Collection A	B	C	Total Number
I	*L. terrestris*	1	0	0	1
	A. caliginosa	0	0	0	0
	E. rosea	0	0	0	0
	Total				1
II	*L. terrestris*	2	1	5	8
	A. caliginosa	3	0	2	5
	E. rosea	1	0	0	1
	Total				14
III	*L. terrestris*	0	1	2	3
	A. caliginosa	4	1	8	13
	E. rosea	1	0	0	1
	Total				17
IV	*L. terrestris*	1	9	3	13
	A. caliginosa	4	1	8	13
	E. rosea	1	0	2	3
	Total				29
V	*L. terrestris*	2	5	3	10
	A. caliginosa	3	8	8	19
	E. rosea	28	41	46	115
	Total				144

the worms, and, in the laboratory, specimens were checked for degree of sexual development, evidence of regeneration, and each individual was measured.

Seasonal changes in field populations have been variously interpreted. Waters (1956) believed that flushes of dead root and herbage debris caused population increases, while the possible exhaustion of food and deleterious soil conditions, such as aeration and soil moisture, might depress the number of earthworms. Hopp (1947) placed considerable emphasis upon freezing of the soil and amount of protection in the form of organic cover, the latter being related to tillage. Evans and Guild (1948) suggested mortality, emergence from cocoons, and

changes in soil temperature and moisture to account for variation in total numbers and composition of the earthworm fauna in farm soils. It may be pointed out again that successful analysis of seasonal activities in earthworms must begin with sampling methods. Any appraisal based upon techniques which do not take into account periods of inactivity or vertical movements of the worms, cannot adequately explain the cyclic behavior which may be present. For these reasons, the wet sampling method was not employed; earthworms were dug from the soil and the latter examined carefully in the field.

FIELD AND LABORATORY RESULTS

The data have been analyzed to show: (1) the season population density (Fig. 4 A), (2) changes in apparent sexual activity (Fig. 4 B), (3) percentage of the population in an active condition (Fig. 4 B), (4) composition of the population with regard to regenerating indi-

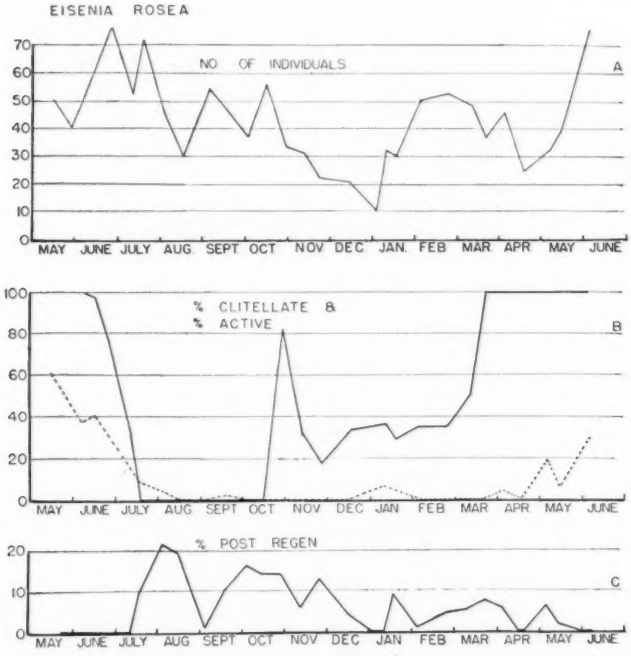


Fig. 4.—Seasonal variation in activities and population density of *Eisenia rosea* at Station V. In B, solid line represents percentages of individuals in each collection in active condition; dotted line, percentages of individuals in the clitellate condition. In C, regeneration is indicated by graphing the percent of individuals in each collection showing posterior regeneration.

viduals (Fig. 4 C), and (5) size analysis over a 12-month period (Fig. 5).

The criterion of sexual activity used in this study was the degree of clitellar development. Separation on the basis of juvenile, immature, mature, etc., cannot be made with certainty because individuals of varying size will become sexually mature and, on the other hand, a regression in sexual activity may make it impossible to determine from external appearance whether the worm is entering the sexual phase or in a state of regression.

There has been an unfortunate use of the term *diapause* (Abeloos and Avel, 1928; Evans and Guild, 1948a; Grant, 1956) to describe periods when certain soil species become inactive. The state is characterized by a cessation of most activities; the worm coils up, often within an earthern cell, and somatic changes may occur. This *diapause* has been identified as "facultative" to indicate response of the worm to unsatisfactory environmental conditions and "obligatory" for a similar performance despite the fact that the soil appears suitable for earthworm activity. Because the term *diapause* infers an understanding of the mechanism involved, I have avoided its use and will refer to worms in this condition as "quiescent."

Earthworm size, as reported, is based upon 10 mm increments; newly emerged individuals thus fall into the 0-10 and 11-20 mm classes. Earthworms were killed and fixed by uniform methods before measurements were made. Counts of newly deposited cocoons which might have served more adequately to determine reproductive activity, proved impossible to obtain due to soil texture. Field methods of recovery of cocoons such as washing and screening were not feasible.

DISCUSSION

Seasonal population density followed a general bimodal curve with the dry summer period representing the trough. Two sizable collections, with more than 50 individuals in each, were taken during this period; one in September, and one in October. That these samples were from unusual concentrations in a population of declining numbers was evident through exploratory collections around Station V.

During the summer period, an attempt was made to find the "missing" population or to determine if mortality could account for the change. Through the wetter spring and winter months, nearly all worms were concentrated in the upper 15 cm of soil; as the soil became dry, larger individuals burrowed deeper into the soil. Thus, although some worms could be found in the upper layers throughout the year, from July through November more and more of the population was not encountered unless digging was extended below the sampling depth of 50 cm. Individuals, on several occasions, were collected at a depth of 130 cm. The maximum depth to which some of these worms may have gone can only be guessed to be several feet.

Individuals of the species *Eisenia rosea* became quiescent as the

soil dried out and all worms were in this condition by mid-July (Fig. 4-B). A rapid recovery of part of the population followed October rains (Fig. 3-E), but a dry period extending into November returned the worms to the inactive state; falling soil temperatures apparently maintained this condition in the bulk of the population. Return to an active condition by much of the population did not result in an increase in the total population. Actually, the October rainfall did not penetrate to the deeper soil layers (40 cm) which remained dry until late November, by which time the upper-soil temperature had fallen to five degrees Centigrade.

A decline in the numbers of fully clitellate worms was coincident with the period of quiescence (Fig. 4 B). It is probable that under suitable moisture conditions a large proportion of the adult popula-

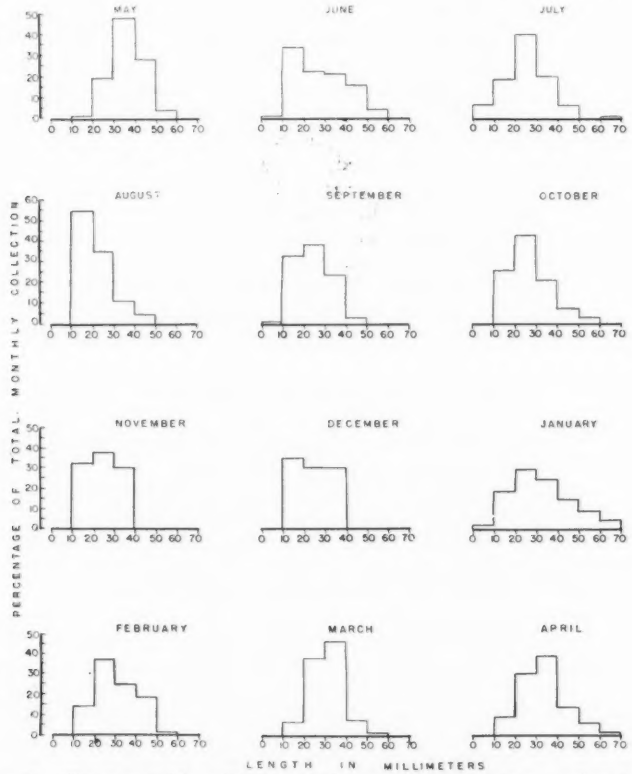


Fig. 5.—Total monthly collection of *Eisenia rosea* plotted according to the percent of individuals falling within certain size limits. Increments of 10 mm were arbitrarily established.

tion would have remained clitellate with cocoon production continuing through much of the summer.

Figure 5 represents a summary of the size analyses on individual worms. Assuming a springtime period of activity and reproduction by *Eisenia rosea*, a paucity of very small worms would be expected in March, April, and May. Emergence from cocoons produced during this period, bringing a rise in the percentage of smaller worms, would be expected to occur in late May and through the summer months. The above conditions are substantially true for the population studied in the Michigan woodlot. From September through December, 1952, there was a departure from what might be termed the "normal expectation" for this species. Among the factors responsible for this were: (1) the downward migration of larger individuals, (2) the entry of many worms, particularly small ones, into a quiescent state with a cessation of feeding and presumably reduction in growth rate, and (3) extension of cocoon life due to deleterious soil conditions.

The latter was clearly evident during early winter months. Inasmuch as reproducing individuals had not been present in the soil for many weeks and even months, it was obvious that low moisture content, low temperatures, or both, had prevented the emergence of the young. These cocoons generally produced young within hours after being brought to the laboratory. Thus, extension of cocoon life can be induced by dryness or cold and may prolong the apparent reproductive period for weeks.

Data presented here show the strong control imposed by the soil environment upon an earthworm population. During the 1952 season, cocoon production was probably initiated by rising temperatures in late spring (Evans and Guild, 1948); emergence of young worms began in June. Almost immediately, the drying of the soil (Fig. 3) caused a downward migration of the larger worms, a movement which was nearly complete by late July and continued into late fall months. Grant (1955) has determined an apparent thermal acclimatization in *Pheretima hupeiensis*. If this condition prevails in *Eisenia rosea*, it might account for the ability of larger individuals to re-enter the upper soil during January, 1953, despite low soil temperatures. Falling soil temperatures during late fall months did appear to prolong the inactive period despite increased moisture content of the soil.

The sudden and substantial increase in the percentage of *Eisenia rosea* showing posterior regeneration (Fig. 4-C) was related to the quiescent state. Abeloos and Avel (1928) were of the belief that posterior regeneration was ruled by the cycle of the "diapause," which depended upon purely internal conditions. Results obtained in my research indicate that, although posterior regeneration is often coincident with this inactive state, the latter is probably induced by an external condition rather than by an inherent rhythm. It is reasonable that the loss of head segments would impose serious restrictions upon activities and reactions of the worm, whereas a larger number of segments may be lost posteriorly without killing the animal nor causing

it to undergo regeneration. Insofar as I am aware, no explanation is available concerning the mechanism which initiates posterior regeneration at the time the worm passes into the quiescent state.

SUMMARY

The summer of 1952 was rather dry and probably masked any inherent rhythm of biological activity possessed by the species *Eisenia rosea*. Data presented do underscore the influence of soil moisture upon activities and population density of earthworms, as well as the need for continuous records of soil moisture in order to demonstrate the moisture "season." It is improbable that specific moisture levels, in terms of percentages, can be used to express toleration limits even in soils of equivalent physical structure and texture.

Part of the variation in population density of *Eisenia rosea* occurring between collection sites may have arisen from the so-called biotic potential of the species. The absence of *E. rosea* from wide areas, however, indicates inadequacy of the soil environment. Several soil factors, including temperature, were found to be reasonably uniform; the moisture regime, on the other hand, showed marked differences. The latter must be described in terms of the amount and length of time soil moisture is available. The qualitative structure of the earthworm population was also related to these variations in soil moisture.

The considerable fluctuation in earthworm numbers from season to season was caused by: (1) migration of larger individuals from the upper soil to lower depths, (2) emergence of young from cocoons, (3) mortality, and (4) dispersion. Vertical movements of oligochaetes can be obscured by improper sampling methods; the rate and time of emergence of young worms may be shifted by the prolongation of cocoon life possible in this group of organisms when external soil conditions are unsatisfactory.

A decline in soil moisture induced worms of the species *E. rosea* to coil up, evacuate the gut, and enter a state of quiescence. No evidence was obtained to indicate that this condition was obligatory; lowered soil temperatures were found to prolongue the inactive period.

Appearance of posterior regeneration in this species was coincident with the onset of quiescence and possibly only occurs during such periods. Analysis of the population of *E. rosea* from the standpoint of individual growth rate was difficult because of the seasonal migration of large worms into deeper soil layers. Thus, a high percentage of the population during summer, fall, and early winter months, was composed of smaller worms. Growth of these worms and a return of the larger individuals to the upper soil, resulted in a percentage decline of small earthworms during February, March, and April, 1953.

Sexual development, as evidenced by the presence of a clitellum, followed the cycle of activity. During the season of 1952-53, this cycle was related primarily to soil moisture and secondarily to temperature. Any inherent sexual rhythm possessed by the species *Eisenia rosea* was probably masked by dry soil conditions.

REFERENCES

ABELOOS, M., AND M. AVEL 1928—Un cas de périodicité du pouvoir régénérateur: La régéneration de la queue chez les Lombriciens *Allolobophora terrestris* Sav. et *Allolobophora caliginosa* Sav. C. R. Soc. Biol. Paris 99:737.

BODENHEIMER, F. S. 1935—Soil conditions which limit earthworm distribution. Zoogeographica 2(4):572-578.

BOUYOUCOS, G. J. 1949—Nylon electrical resistance unit for continuous measurement of soil moisture in the field. Soil Sci. 67:319-330.

DARWIN, C. R. 1881—The Formation of Vegetable Mould through the Action of Worms with Observations on their Habits. J. Murray, London. 328 pp.

EVANS, A. C., AND W. J. MCL. GUILD 1947—Studies on the relationships between earthworms and soil fertility. I. Biological studies in the field. Ann. Appl. Biol. 34(3):307-330.

———1948—Studies on the relationships between earthworms and soil fertility. IV. On the Life Cycles of Some British Lumbricidae. Ann. Appl. Biol. 35(4):471-484.

———1948a—Studies on the relationships between earthworms and soil fertility. V. Field Populations. Ann. Appl. Biol. 35(4):485-493.

GRANT, W. C. 1955—Temperature relationships in the Megascolecid earthworm *Pheretima hupeiensis*. Ecol. 36(3):412-417.

———1956—An ecological study of the peregrine earthworm *Pheretima hupeiensis*. Ecol. 37(4):648-658.

GUILD, W. J. MCL. 1952—Variation in earthworm numbers within field populations. Jour. Animal Ecol. 21(2):169-181.

HOPP, H. 1947—The ecology of earthworms in cropland. Soil Sci. Soc. Amer. Proc. 12:503-507.

MURCHIE, W. R. 1956—Survey of the Michigan Earthworm Fauna. Mich. Acad. Sci. Arts. Lett. Pap. (1953) 41:53-72.

OLSON, H. W. 1928—The earthworms of Ohio. Ohio Biol. Sur. 4(2) Bull. No. 17:47-90.

PIPER, C. S. 1947—Soil and Plant Analysis. Interscience Publishers, New York. 368 pp.

PRUITT, W. O. 1952—A method for mounting thermistors for field use. Ecol. 33(4):550.

SATCHELL, J. E. 1955—Some aspects of earthworm ecology. Soil Zoology. Butterworths Sci. Publ., London.

SMITH, F. 1917—North American earthworms of the family Lumbricidae in the collection of the U.S. National Museum. U.S. Nat. Mus. Proc. 52:157-182.

VEATCH, J. C., L. C. WHEETING, AND ARNOLD BAUER 1930—Soil survey of Washtenaw County, Michigan. U.S. Dept. Agr. in co-op. with Mich. Agr. Exp. Sta. Ser. 1930, 21:1-47.

WATERS, R. A. S. 1955—Numbers and weights of earthworms under a highly productive pasture. New Zealand Jour. Sci. and Tech. 36(5):516-525.

Identification of Asiatic Species of Phaseolus by Seed Characters

BERNARD M. LEESE, JR.
United States Department of Agriculture, Washington, D. C.

In the ancient civilizations of eastern and southern Asia certain species of *Phaseolus* played a very important role, constituting a staple food for the greater part of the population. At present these Asiatic beans continue to occupy a position of great importance in the diet of the Oriental people and are being utilized more and more throughout the rest of the world. Prepared foods containing sprouted Asiatic beans for example, are gaining steady in popularity, particularly sprouts of the mung bean *P. aureus*. The plants are also important for green manure and forage in the Old World and are being increasingly used for the same purposes in the United States.

These Asiatic species of *Phaseolus*, of which eight are recognized at present, appear in commerce as seeds. Some of the seeds are so similar in structural characters that a seed key is presented herein, together with detailed descriptions.

The botanical names of these plants are as follows: *P. aconitifolius* Jacq. (moth bean), *P. angularis* (Willd.) W. F. Wight (Adsuki bean), *P. aureus Roxb.* (mung bean), *P. calcaratus* Roxb. (rice bean), *P. mungo* L. (Urd), *P. radiatus* L., *P. scaberulus* Miquel and *P. trilobatus* (L.) Schreb.

Acknowledgment.—Dr. Sidney F. Blake, Dr. Frederick J. Hermann, and Mr. P. G. Russell, U.S.D.A., Plant Introduction Section, kindly reviewed and checked the species mentioned in this paper. I am indebted to them for their aid.

Glossary of Terminology

The terminology for the macroscopic structure of seeds is frequently so inadequate or misleading that it is difficult or nearly impossible to describe satisfactorily seeds of a given species. It becomes necessary, therefore, to coin special terms for the sake of precision. The terms used in this paper may be defined as follows:

Caruncle.....A wart-like excrescence formed on the collar surrounding the hilum cushion; this may appear as an elevated line or as a lobed mantle, usually hard and horny in texture. (See Figs. 9 and 10.)

Cotyledon ridge.....A ridge produced by the meeting of the two cotyledons. (See Figs. 9 and 10)

Hilum cushion.....A wart-like excrescence bridging the hilum, composed of a spongy flaky material, and differing from the caruncle in the shape of the cells and texture.

Hilum line.....A line encircling the floor of the hilum, usually an attachment of the hilum cushion; this is visible after removal of the caruncle and hilum cushion.

Hilum slit.....A slit, usually a lighter color than the hilum floor, running along the center of the greater axis of the floor of the hilum; characteristic of the Leguminosae.

Micropyle.....An ostiole usually elevated on the radicle side next to the hilum.

Palisade ridge.....A ridge produced by the restricted growth of the seed coat due to the doubling of the palisade cells and surrounding the hilum proper. (See Figs. 9 and 10.)

Sclerenchyma bundle.....A bundle of tissue below the hilum floor, consisting of cells much lighter in color than the surrounding cells and visible in cross-section. (See Figs. 9 and 10.)

Parahilum.....A small area next to the hilum, characterized by two small tubercles; the area usually contrasts in color or texture with the rest of the seed coat; often referred to as a strophiole.

GENERAL CHARACTERISTICS OF ASIATIC SPECIES OF PHASEOLUS

The Asiatic beans possess the following common characters: Annual plants; stipules with a basal appendage; flowers yellow, left keel of petal spurred; keel spirally coiled, bearing on one side a horn-like appendage; style hairy above, prolonged into a narrow appendage beyond the stigma; stigma lateral, subterminal.

The seeds are globose to subcylindrical, or slightly laterally compressed, ovoid, subtruncate at both ends, and slightly longer than broad. The general contour is even except in *P. scaberulus*. The cross-section varies from circular or subquadrangular to cordate, with *P. radiatus* showing a distinct cotyledonous ridge, (possibly due to dehydration). The hilum is marginal, covered with a grayish white spongy hilum cushion; in *P. angularis, P. calcaratus,* and *P. mungo* the hilum cushion is surrounded by a caruncle, usually of a lighter color than the hilum cushion. The seeds range from approximately 3.2 mm. (*P. trilobatus*) to 10.0 mm. long (*P. calcaratus*).

The hilum, located on the ventral margin, is eccentric. It is ovate to obovate, the greatest width being toward the micropyle end of the seed. It is depressed except in *P. calcaratus*. The floor of the hilum is either flat (*P. aconitifolius, P. aureus* and *P. scaberulus*), convex (*P. calcaratus, P. mungo, P. radiatus,* and *P. trilobatus*) or concave (*P. angularis*).

The caruncle differs from the hilum cushion in the color or the shape of the cells which can be seen with a 20-X lense. The caruncle cells are elongate and are formed on the outside of the hilum cushion which is composed of more or less spherical cells. The caruncle is of lighter texture than the hilum cushions. The parahilum and micropyle, discussed later, are both located close to the hilum. The micropyle, when discernible, appears elevated and opens toward the hilum

(*P. aconitifolius, P. aureus, P. radiatus,* and *P. trilobatus*). The micropyle is located at the radicle end of the hilum.

The parahilum located at the opposite end of the hilum, is clearly evident as two tubercles, usually of different texture or color from the rest of the seed coat. It is slightly raised (umbonate) and the furrow between the two tubercles varies in length. In *P. aconitifolius* it has a very definite outline produced by the pigmentation on the two umbonate surfaces.

The seeds of this group vary in color from shining brownish yellow or brownish red to dull brownish black. The seed color of a single species may vary considerably, depending upon the stage of development and environmental factors. Seed color may be used as a secondary character for identification in connection with the basic characters. Change in color with increasing age is characteristic of the light-colored seeds. After a year or so in storage such seeds lose their bright appearance as a result of oxidation. The seed coats of most of the species, except *P. radiatus* and *P. trilobatus,* are shining and rather smooth. The former has a scaly mealy substance over the seed coat, and *P. trilobatus* has a dusty cutin-like substance giving the seed a dull appearance.

The seeds of Phaseolus are amphitropous and usually described as exalbuminous, but actually the seed has a very thin endosperm with fleshy cotyledons and a small radicle.

The hilum is obovate or ovate, usually covered with a caruncle and/or hilum cushion. Two small tubercles posterior to the hilum, frequently called the strophiole, are here called the parahilum. The raphe forms a more or less distinct ridge from the hilum to the indistinct chalaza, the micropyle being on the other side of the hilum. The radicle is small, often showing through the testa. The parenchyma of the testa is usually spongy and the sclerenchyma bundle under the scar is always evident.

MATERIAL

Descriptions of the different species were made from the material indicated.

P. aconitifolius—Nineteen samples were observed. Eighteen were collected near Poona, India; one collected in Afghanistan. Two of the samples were darker in color and mottled. All samples appeared to be well preserved.

P. angularis—Twenty-nine samples were considered. Eighteen of these were collected around Echo and Chihli, China: seven near Harbin, Manchuria; and four in India. Some of the samples were mottled and a very few were a light yellowish brown color; this light coloration often appears to be an indication of immaturity.

P. aureus—Fifteen collections were reviewed. One seed sample from the Soviet Union, one from China, four from India, three from Iran, one from the Union of South Africa, one from Turkey, one from

Australia and three from the United States. All samples were well preserved.

P. calcaratus—Seventy-two collections, most of which were from China, and a limited number from the Philippines, Burma, Japan, and Java, were studied. All material appeared to be in excellent condition.

P. mungo—Forty-three collections were seen, most of which were collected in India. One seed collection from India was outstanding in appearance because of the black mottled shining seed coat. A collection made in China had a caruncle unlike the characteristic irregular caruncle. All samples were well preserved.

P. radiatus—Two collections, one from Italian Somaliland and the other from Bruitenzorg, Java, were examined. The seeds were not well preserved and deterioration was evident. The measurements and shape used in the description of the seed may have been influenced by the deterioration; however, this condition would have little effect on the characters used in the key.

P. scaberulus—One collection was made in Sumatra. Some wrinkling was present; this may be characteristic of the dry mature seed.

P. trilobatus—Two collections were observed, one from China and one from India. Both were well preserved.

SEED KEY OF ASIATIC SPECIES OF PHASEOLUS

A synoptical key, description or illustration should be considered as a crutch and, in this case, it is a resumé of an artificial arrangement or convenient grouping of seeds with very similar characteristics which may differ somewhat according to the variety.

A. Hilum scar flush with the surface of the seed coat; caruncle conspicuous, 2.5-4.5 mm long; micropyle usually obscure ..... *P. calcaratus*

A. Hilum scar depressed below the surface of the seed coat; caruncle small or missing; micropyle always evident ..... (B)

B. Hilum floor concave; seed 5.0-7.5 mm long ..... *P. angularis*

B. Hilum floor flat or convex; seed usually less than 5 mm long ..... (C)

C. Hilum floor flat; seed never mottled ..... (D)

D. Hilum cushion flush with the surface of the seed coat; not over 0.4 mm wide; seed coat dull brown to light brown ..... *P. aconitifolius*

D. Hilum cushion convex or elevated above the surface of the seed coat; hilum over 0.4 mm wide ..... (E)

E. Hilum 1.3-1.8 mm long, 0.5-1.6 mm wide; seed globose to subglobose; seed coat green to golden brown and covered with a farinose material; cotyledon ridge not evident, sometimes replaced by a lighter colored area ..... *P. aureus*

E. Hilum 2.3-2.6 mm long, 0.8-0.9 mm wide; seed rectangular to cylindrical, somewhat irregular; seed coat reddish-brown and smooth; cotyledon ridge evident ..... *P. scaberulus*

C. Hilum floor convex; seed frequently mottled; seed coat covered with cutin-like or farinose coating ..... (F)

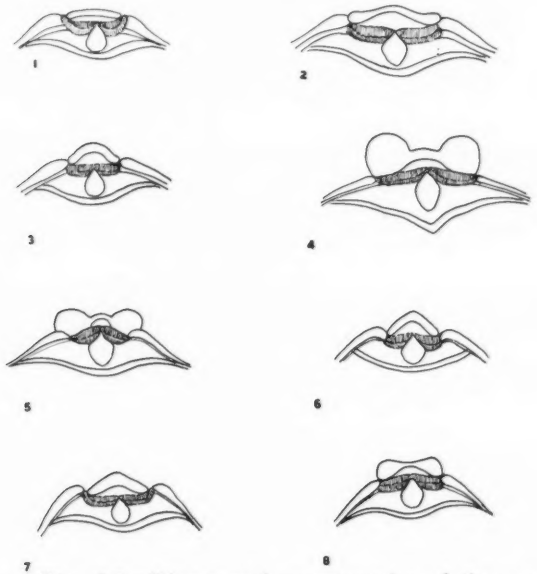
f. Caruncle present and irregular; parahilum defined by differentiation in color; seed over 4.0 mm long; palisade ridge evident; cotyledon ridge not evident ..... *P. mungo*
f. Caruncle absent; parahilum not well defined; seed less than 4.0 mm long; palisade ridge not evident; cotyledon ridge evident ..... (g)
g. Micropyle and parahilum area tinged reddish; seed coat covered with a cutin-like material ..... *P. trilobatus*
g. Micropyle and parahilum without reddish tinge; seed coat covered with a farinose material ..... *P. radiatus*

Description of Seed Characters

P. aconitifolius (moth bean; Figs. 1 and 11).

Seeds 3-4.5 mm. long and 2-2.5 mm. wide, cylindrical, distinctly elongate, more or less subtruncate at each end. Hilum margin slightly concave. Cotyledon ridge evident. Seeds light yellowish-brown or light-brown, rarely mottled. Average weight 0.03 gram.

Hilum 1.2 mm. long, approximately 0.4 mm. wide, laterally com-



Figs. 1-8.—Diagrammatic representation of the cross section through the hilum of eight species of *Phaseolus*. 1.—*P. aconitifolius*. 2.—*P. angularis*. 3.—*P. aureus*. 4.—*P. calcaratus*. 5.—*P. mungo*. 6.—*P. radiatus*. 7.—*P scaberulus*. 8.—*P. trilobatus*.

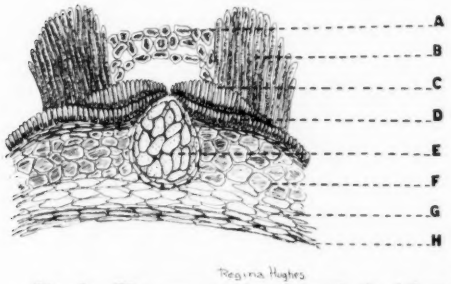


Fig. 9.—The cross section through the hilum of *Phaseolus mungo* (see Fig. 5), showing the general cell characteristics. (Generally enlarged.) A, hilum cushion; B, caruncle; C, palisade layer (1); D, palisade layer (2); E, sclerenchyma bundle; F, modified outer parenchyma; G, outer parenchyma; H, inner parenchyma.

pressed, somewhat narrowly obovate with the base at the micropyle. Hilum line deep brown framing the hilum cushion and becoming coarse toward the micropyle. Hilum excentrically located, 1.6 mm. from the micropyle and 1.92 mm. from the parahilum end. Floor flat and depressed, characteristic hilum slit evident. Palisade ridge surrounding the hilum and hilum line lighter brown than the hilum, or the umbonate ridges of the parahilum, but a deeper, richer brown than the seed coat. Hilum cushion (grayish-white spongy tissue) flush with the surface of the seed coat. Micropyle at the base of the claviform hilum elevated by the bulky radicle, not conspicuous. Micropyle pore not evident, no distinction in color surrounding the area. Parahilum elongate-lanceolate, measuring approximately 0.9 mm. long. Two umbonate margins deep brown, separated by a light-clay colored sulca line. Parahilum evident.

Sclerenchyma bundle beneath the hilum 0.02 mm. in diameter.

P. aconitifolius is native to India, growing wild from Ceylon to the Himalayas. It is generally cultivated as a hot-weather crop and is considered an extremely hardy plant. The moth bean in India is a capital "grain," a first-class fodder and a green manure plant.

P. ANGULARIS (Adsuki bean; Figs. 2 and 11).

Seeds 5-7.5 mm. long and 4-5.5 mm. wide, cylindrical to cordate, often rounded-quadrilateral to subtrapeziform, appearing rectangular, slightly rounded at the ends. Hilum margin slightly convex. Micropyle end compressed, forming an obtuse angle leaving the micropyle area somewhat elevated. Cotyledon ridge evident (more so than in *P. acontifolius*). Seed coat usually dark wine, occasionally buff,

black or mottled (black on red or black on beige). Seed coat smooth. Average weight 0.07 gram per seed. Hilum 2.4-3.3 mm. long and 0.6-0.8 mm. wide conforming to the seed margin, slightly elongate to narrowly obovate at the base of the micropyle. Hilum line covered by a thin striped caruncle barely distinguishable from the hilum cushion, which is irregularly convex and attached at the base of the caruncle.

Hilum excentrically located 1.2-3.0 mm. (depending upon how acute the angulated end may be) from the parahilum end and 0.9-1.7 mm. from the micropyle end. Floor concave. Hilum slit evident. Hilum cushion attached at the base of the caruncle, irregularly convex cells coarse in texture. Caruncle a somewhat inconspicuous spongy line framing the hilum cushion; cells elongate. Micropyle evident, pore countersunk. Parahilum 0.5-0.6 mm. long, wedge-shaped, the umbonate margins usually concolorous. Sclerenchyma bundle 0.18 mm. in diameter.

P. angularis is native to India. It is cultivated in northern China and Japan, where it is eaten boiled with soup or mixed with rice.

P. AUREUS (Mung bean, Figs. 3 and 11).

Seeds 3.2-5 mm. long and 3-3.8 mm. wide, oblong and slightly flattened, more or less spherical or nearly square, rounded on the edges, usually green, seldom golden brown; immature seeds usually brown and wrinkled. Hilum margin slightly concave. Micropyle end compressed forming an obtuse angle, hypocotyl and micropyle somewhat

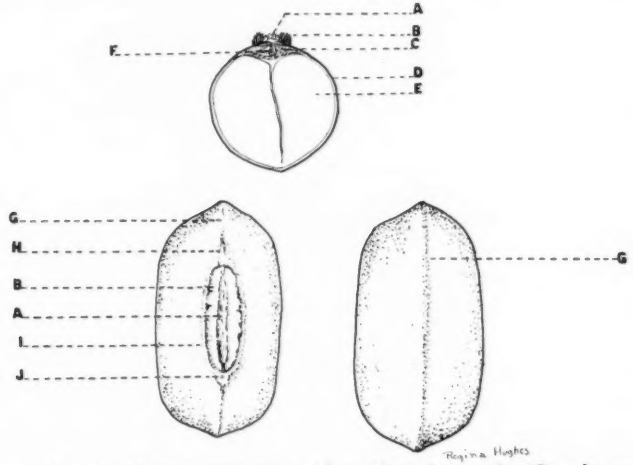


Fig. 10.—Macroscopic parts of a *Phaseolus* seed. (Greatly enlarged.) A, hilum cushion; B, caruncle; C, palisade cells; D, seed coat; E, cotyledon; F, sclerenchyma bundle; G, cotyledon ridge; H, parahilum; I, palisade ridge; J, micropyle.

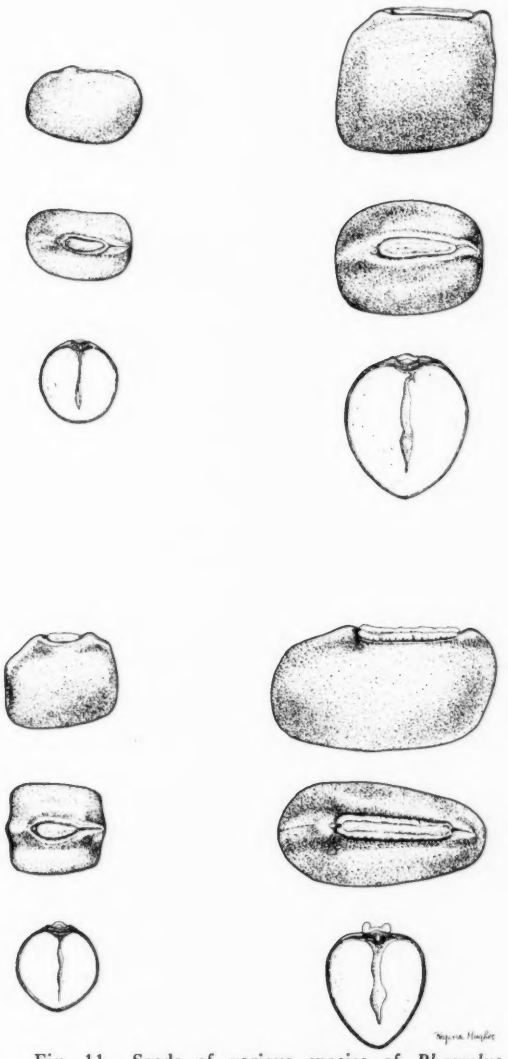


Fig. 11.—Seeds of various species of *Phaseolus*. Lateral, ventral and sagittal views, x4. Upper left, *P. aconitifolius;* upper right, *P. angularis;* lower left, *P. aureus;* lower right, *P. calcaratus.*

elevated. Cotyledon ridge inconspicuous; lighter color marking the union of the two cotyledons seldom apparent. Seed coat with light colored farinose (mealy) material giving the otherwise smooth surface a dull, coarse semi-polished look. Surface usually marked with fine crenulate lines. Average weight 0.4 gm per seed. Hilum 1.3-1.7 mm. long and 0.5-0.6 mm. wide, narrowly obovate, the base at the micropyle, somewhat centrally located 1.0-1.8 mm. from the micropyle end and 1.1-1.7 mm. from the parahilum end. Evaginated line forming an attachment for the hilum cushion. Floor flat and depressed, characteristic hilum slit evident. Palisade ridge usually of a deeper shade than the seed coat. Hilum cushion (yellowish-white spongy tissue) elevated above the seed surface, convex laterally and longitudinally. Micropyle elevated and evident, pore facing hilum.

Parahilum 0.7-1.2 mm. long, very evident, sharply defined by the deep brown coloration on the two umbonate margins. Sclerenchyma bundle 0.14-1.15 mm. diameter.

P. aureus is native to India. The plant is one of the very ancient crops of India and still is an important source of food. The seed is highly nutritious and the green pods also are eaten. Over a hundred varieties are grown in China and other Asiatic countries. In the United States this crop plant is increasing in importance as a forage plant and as a green manure crop.

P. CALCARATUS (Rice bean; Figs. 4 and 11).

Seeds 5-10 mm. long, 2-5 mm. wide and 3-6.5 mm. along the lateral margin, oblong to strongly elongate, subtrapezoidal. Cross section cordiform and laterally compressed. Hilum margin slightly concave. Cotyledon ridge very distinct. Seeds dark wine, colored brown, light brown or cream, occasionally mottled and then much larger (possible hybrids). Seed coat smooth, semipolished. Average weight 0.05 gm per seed. Hilum 2.5-4.5 mm. long and 0.6-1.5 mm. wide, strap-shaped, flush with the seed coat and convex laterally making the longitudinal slit elevated above the surface of the margin of the seed coat, covered by a double-ridge caruncle diverging from the center of the hilum, somewhat cymbiform and irregular with a notch or slit at the micropyle end, excentrically located 0.2-1.2 mm. from the parahilum end and 2.3-3.0 mm. from the micropyle end.

Palisade ridge not apparent but replaced by a distinctive coloration of the seed coat. Light seed coats usually have a deep color around the hilum and dark seed coats have a light coloration around the hilum. Caruncle, the most conspicuous part of seed, corneous-granulated in texture, somewhat boat-shaped and irregular in form, appears to be resting on the seed. Micropyle usually hidden by the caruncle and located at the base of the radicle hump. Micropyle not elevated (as in most of the other Asiatic *Phaseolus* species). Pore evident, distinguished by the color and texture. Parahilum evident, usually occu-

pying the terminal margin from the hilum to the end. Two umbonate margins of the parahilum and the immediate area also distinguished by contrasting coloration. Sclerenchyma bundle 0.13-0.15 mm. in diameter, well defined.

P. calcaratus is native to Mysore, India. The plant is cultivated and wild throughout the tropical zone from the Himalayas to Ceylon

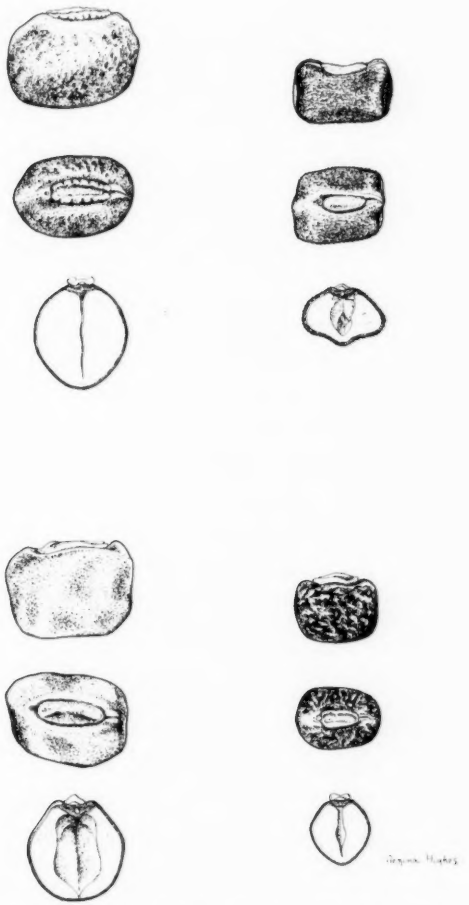


Fig. 12.—Seeds of various species of *Phaseolus*. Lateral, ventral and sagittal views, x4. Upper left, *P. radiatus;* upper right, *P. mungo;* lower left, *P. scaberulus;* lower right, *P. trilobatus.*

where it is used for human food and cattle fodder. Two forms are said to exist, one with a red seed coat and the other with a cream seed coat. Careful examination revealed three forms, the third being a much larger mottled seed, evidently a hybrid. One form of *P. calcaratus* has been named *P. trinervius* adding to the confusion in the status of this species.

P. MUNGO (Figs. 5 and 12).

Seeds 4.0-5.2 mm. long and 3.5-4.1 mm. wide, cylindrical to ovoid-oblong and slightly truncate at each end, more so at the parahilum end. Hilum margin concave, elevated at the micropyle end (in *P. aureus* the parahilum end is elevated). Micropyle end compressed, forming an obtuse angle. Cotyledon ridge inconspicuous. Micropyle obscured by the caruncle (in *P. aureus* it is evident). Seeds usually dark and mottled, occasionally dull brown or dull green. Seed coat covered with a mealy or powdery (farinose) material giving a dull semi-polished appearance. Average 0.4 gm per seed.

Hilum 1.2-2.3 mm. long and 0.7-1.1 mm. wide, laterally compressed, narrowly obovate with the base at the micropyle, excentrically located 1.3-2.1 mm. from the parahilum end and 1.1-1.8 mm. from the micropyle end. Floor convex and nearly flush with the seed coat, hilum slit evident and characteristic. Palisade ridge not conspicuous (not as evident as in *P. aureus*) with little or no distinction in color. Hilum cushion apparently originating from the surrounding caruncle which is more dull in appearance. A bridge is formed by the hilum cushion. Caruncle situated more or less on top of the hilum margin of the seed attached to the margin of the scar; horny-granulated in texture diverging from the center of the hilum, somewhat cymbiform and irregular in outline with a fine slit at the parahilum (in *P. calcaratus* the slit is at the micropyle). Micropyle bordering the hilum, elevated to such an extent that the concave hilum margin appears to be elevated on the micropyle end. Micropyle pore slanted toward the hilum, little distinction in color surrounding the micropyle. Parahilum evident and usually occupying all the terminal margin from the hilum to the end of the seed. The two umbonated margins are 1.4-1.7 mm. long. Sclerenchyma bundle beneath the hilum 0.12x0.15 mm., cross section ovate.

P. mungo is native to India. The plant is commonly cultivated in India and the Nile valley, where the green pods are eaten as a vegetable. The seeds are used boiled whole or split like "dál." Parched and ground the flour is made into balls with spices, or employed for making a sort of porridge for bread. The seeds have a pleasant taste and are wholesome and nutritious. The urd is valued as food for livestock and is considered very fattening. It has merits as a fodder and green manure plant. The flour from the seed is said to be an excellent substitute for soap, leaving the skin soft and smooth, and is an invariable concomitant of the Hindu bath.

P. RADIATUS (Figs. 6 and 12).

Seeds 2.8-3.6 mm. long and 2.6-3.0 mm. wide, somewhat cylindrical to cubical; angles not well defined, abruptly truncate at the micropyle and parahilum end, wider at the micropyle end. Hilum margin concave. Cotyledon ridge distinct. Seeds mottled with two shades of brown, a brown mealy material on the seed coat giving the seed a rugose appearance. Average weight 0.0009 gram. Hilum 1.5-2.0 mm. long and 0.4-0.6 mm. wide, oblong-elliptical, covered by a brown soft spongy hilum cushion. Hilum line surrounding the laterally convex hilum floor and acting as an attachment for the hilum cushion; hilum slit evident. Hilum centrally located between the parahilum end and the micropyle end. Palisade ridge not evident, concolorous. Hilum cushion appearing to have its origin at the hilum line surrounding the hilum floor, brownish-gray, similar in color and texture to the hilum cushion in *P. trilobatus*. Micropyle evident, slightly elevated; pore opening towards the hilum. Micropyle distinguished by an area of lighter brown. Parahilum not well defined, usually occupying the angle of the truncation, the two umbonate margins 0.5-0.6 mm. long. Sclerenchyma bundle 0.12-1.18 mm. diameter, somewhat ovoid in cross section.

P. radiatus is native to India.

P. SCABERULUS (Figs. 7 and 12).

Seeds 3.8-4.5 mm. long, 3.0-3.5 mm. wide and 2.8-3.4 mm. along the lateral margin, nearly rectangular to cylindrical, somewhat truncate at each end, irregular in form, ovate in cross section. Hilum margin concave. Cotyledon ridge evident. Seeds reddish-brown, smooth, somewhat shining in appearance. Average weight 0.4 gram.

Hilum 2.3-2.6 mm. long and 0.8-0.9 mm. wide, indented below the seed coat, narrowly obovate and covered by a grayish-white hilum cushion (similar to *P. aureus*). Floor flat to slightly convex. Hilum excentrically located 0.5-1.5 mm. from the parahilum end and 1.1-1.5 mm. from the micropyle end. Palisade ridge not distinct, but the area sharply outlined by deeper color. Hilum cushion composed of grayish-white spongy tissue, elevated above the surface of the seed coat, convex laterally, attached above the hilum floor leaving an air space between the hilum cushion and the hilum floor. Micropyle elevated, quite evident. Parahilum evident, usually occupying all the terminal margin from the hilum to the end of the seed. Umbonate margins indicated by a lighter brown color. Sclerenchyma bundle 0.15 mm. in diameter, slightly elliptical. In a cross section of the seed the cotyledons are seen to be navicular, forming a cavity which is quite evident.

P. scaberulus is native to Java.

P. TRILOBATUS (Figs. 8 and 12).

Seeds 2.5-3.2 mm. long and 1.8-2.4 mm. wide, cylindrical to oblong, truncate at each end, wider at the micropyle end than at the parahilum end (a characteristic of *P. radiatus* also). Hilum margin concave, somewhat flattened, nearly flush with the seed coat; hilum line usually evident as an attachment of the hilum cushion. Micropyle elevated more than the parahilum. Seed coat mottled, predominant colors beige, light brown or black, dull and rugose due to a cutin-like coating. Average weight 0.008 gram.

Hilum 1.3-1.7 mm. long and 0.6-0.72 mm. wide, the margin concave, oblong-ovoid in outline and nearly flush with the surface of the seed coat. Floor slightly convex laterally. Hilum slit evident, located 0.4-0.6 mm. from the parahilum end and 0.5-1.0 mm. from the micropyle end of the seed. Palisade ridge not evident. Hilum cushion bridging the floor, attached at the hilum line, usually having rolled edges, slit at the parahilum end. Micropyle evident, elevated, pore opening toward the hilum. Micropyle and parahilum area characterized by a reddish tinge of the seed coat. Parahilum evident, slightly umbonate, characterized by reddish tinge. Cotyledon ridge evident. Sclerenchyma bundle 0.15 mm. in diameter, slightly elliptical.

P. trilobatus is native to India, Malaya and possibly East Tropical Africa.

Certain Aspects of Behavior of the Black-tailed Jack Rabbit

R. R. LECHLEITNER[1]
Museum of Vertebrate Zoology, University of California

The black-tailed jack rabbit (*Lepus californicus*) inhabits the western United States from Iowa to the Pacific coast. It is found throughout California and ranges from below sea level in Death Valley to 12,500 feet in the Sierra Nevada mountains (Orr, 1940). The hare densely populates some areas. It is a crop depredator, a game animal and a carrier of diseases, and hence is ecologically and economically important. However, little detailed information is available about the behavior of this lagomorph.

A sample population of this hare was studied from October, 1954, to March, 1956, on the Gray Lodge Waterfowl Management Area, Butte County, California. This area includes 6,800 acres of land which is managed by the California Department of Fish and Game. About one-third of the area is permanent ponds and marshes, and much of the remainder is planted in crops such as rice, millet and milo. Jack rabbits are abundant on the area. During this study the population density was estimated to be about one hare per acre of suitable habitat (Lechleitner, 1956).

Over 100 of the jack rabbits were captured in live traps, using apples and commercial rabbit pellets as bait. Each captured animal was marked by attaching two connected plastic discs, with numbers engraved and painted on them, in one of its ears. One disc was placed on the outside of the ear and the other on the inside. If the animal was a female, the discs were placed in the left ear; if it was a male, they were placed in the right ear. Identified hares were released. Observations of both marked and unmarked hares were made by using 6-power binoculars and a 20-power telescope. The details of the trapping and marking methods will be reported in another paper.

The purpose of this paper is to present observations of the behavior of the free-ranging hares, with the hope that this information will add to our general knowledge of the biology of this animal.

ACKNOWLEDGMENT.—I extend my sincere appreciation and thanks to all who aided me in this study. Special thanks are given to Mr. John Cowan and the personnel of the Gray Lodge Waterfowl Management Area as well as to Dr. A. S. Leopold, Dr. O. P. Pearson, Dr. W. C. Reeves, and Dr. R. D. Taber of the University of California at Berkeley, all of whom aided me in many ways. I am grateful to the Museum of Vertebrate Zoology and the Zoology Department of the University of California at Berkeley for the donations of funds and equipment used in the study.

[1] Present address: Department of Zoology, Colorado State University, Fort Collins.

SOCIAL ORGANIZATION

It is believed that observed aggregations of jack rabbits were mainly motivated by suitability of habitat and food rather than by social organization. Associations of up to 50 individuals were observed feeding in the same field. When these aggregations were alarmed, they dispersed randomly. No pattern of organized groups or herds could be observed. When they returned to the feeding grounds, the individuals were spaced in a different pattern from that which was observed before they were disturbed. Furthermore, marked animals did not remain closely associated, even when they were originally collected at the same trapping site.

The only semblance of family structure among the jack rabbits exists between the young and the mothers. Even these dependent interactions cease to exist by the time the young are weaned. No interdependent relationships could be found between the half-grown and the fully-grown animals.

Complete data are lacking on the interactions between the mother and the very young, but undoubtedly the young are cared for by the mother until they are weaned. Young which are less than one-third to one-half grown are extremely wild and seldom seen. It has been suggested that they are wilder, more nocturnal and less motivated to leave their hiding places than are the adults (Vorhies and Taylor, 1933).

Only one nest was found during this study. This consisted of an unlined shallow depression in the ground and resembled the forms used by the adults. Several young individuals were found in dense grasses and weeds. These were not in a nest, but were crouched at the base of weeds. They remained motionless until approached to within a few inches; they then crept a short distance away and crouched again. Vorhies and Taylor (1933) report several nests which were sunk into the ground to a depth of eight inches and lined with fur. Many of the nests were invisible except when plowed up. This suggests that they had been partly covered by the mothers before they left them.

The personnel on Gray Lodge reported frequent observations of very small jack rabbits while plowing the fields. Since the fields are plowed in concentric furrows working from the periphery toward the center, they frequently found concentrations of the young hares in the center of the field as the plowing was finished.

Most of our knowledge of the habits of young jack rabbits comes from observations made in captivity. Several young were raised during this study. These were very active at night and remained almost motionless during the day. This pattern of behavior persisted until they were about two months old. At this time a gradual change to more diurnal habits occurred. These observations agree with those made by Vorhies and Taylor (1933) and Haskell and Reynolds (1947), and suggest that under natural conditions mother-offspring contacts occur at night when observations are difficult to make.

FOODS AND FEEDING

A limited study was made of the foods eaten by jack rabbits on Gray Lodge. Arnold (1942) has described the amounts eaten and the food preferences of captive Arizona jack rabbits. He has shown that, when competition is direct, 62 ± 7 black-tailed jack rabbits can be expected to consume the equivalent forage of a 1000 pound range cow. He further indicated that jack rabbits eat about equal portions of grasses and weeds, thus suggesting they may prefer weedy ranges to those of pure grass.

The jack rabbits on Gray Lodge apparently will eat almost any of the grasses or weeds found there. Their preferred foods are the various cereal crops and the most preferred is young barley; however, when the barley attains a height of four or more inches, the hares gradually shift to some other plant or plants. This preference for young, succulent plants was expressed for the other species of plants which the hares ate.

Almost all of the weeds on the area were eaten by the hares at some time, but none of them seemed to be a preferred item of diet. They occasionally ate yellow star thistle (*Centaurea salstitialsis*) even when it was brown. In December, 1955, and January-February, 1956, heavy rains flooded the fields. The hares were forced to occupy unflooded levees and roads where they ate almost every kind of plant available. One of the plants eaten in great quantities at this time was mallow (*Malva* sp.). A majority of the mallow plants along the roads and levees were stripped completely of leaves and even the stems were eaten. This intensive foraging seems more a response to strong hunger and availability than to discriminating preference. Prior to this time no heavy foraging of mallow was noticed. After the waters receded, curly dock (*Rumex crispus*) appeared in great quantities in some of the fields. The large basal leaves of this plant provided the principal food for the hares when they first returned to the fields. As the fields recovered, many small green plants appeared and were eaten in place of dock.

Jack rabbits prefer to feed in open areas which have a supply of succulent young plants. These areas, near dense patches of weeds, were the places of the greatest concentrations of jack rabbits. Undoubtedly, the interspacing of patches of dense weeds and open areas provides preferred jack rabbit habitat.

The peak of feeding activity occurred in the evening. However, depending upon the time of the year and the weather, jack rabbits may be seen feeding at any time of the day and night. As dusk approached the hares could be seen converging upon open areas from resting places in the surrounding weeds and from banks and levees. Active feeding may continue well into the night. However, night observations with a light indicate that there may be a period after which feeding activity is reduced, or may cease. Later in the evening hares were noted to rest or even sleep. The exact length of the evening

feeding period is not known. Observations indicate that it varies greatly with such factors as weather, time of the year, and phase of the moon. On bright moonlight nights hares were seen feeding as late as 1:00 a.m., whereas little feeding activity after 11:00 p.m. was ever noticed on dark nights. Calm, dry evenings appeared to be more favorable for longer feeding periods than did windy, wet evenings.

GENERAL CHARACTERISTICS OF BEHAVIOR

Jack rabbits rest in a variety of situations but never underground. At times they construct depressions in the ground to a depth of several inches. At other times the grasses and weeds simply are pushed aside, making a space for the body. Such resting places are referred to as forms (Vorhies and Taylor, 1933). The pattern of construction and use of forms is variable. Henry (1942) noted that the forms made by jack rabbits in Iowa were located on the western slopes and higher contours of fields. No such dispersion could be detected on Gray Lodge. If there was any location which was preferred, it seemed to be along the levees and roadsides, but the locations varied so much with the time of year, stage of the vegetational growth, and the weather that it is difficult to generalize. During the hot summer months there was a definite grouping of forms under the willow and cottonwood trees bordering the canals, but in the cooler months of the year forms were more widely dispersed over the fields. The forms were often at the bases of large plants and seemed to be oriented to give maximum protection from the hot sun or high winds.

In general, the jack rabbits sat with the haunches to the rear of the form (i.e., base of the plant) and the head toward the open end. From observations of marked hares it became evident that the forms were used more than once, sometimes by the same animal and sometimes by other jack rabbits.

The jack rabbits rested not only in forms, but also squatted in the open in a hunched-up position with the ears lowered on the back. On warm sunny days of early spring hares were frequently seen sitting and dozing in this matter, or stretched on their sides. When the sun became warmer, they sought the shade of weeds or trees.

The hares spent much of the resting time cleaning themselves. During cleaning, they licked all areas of the body which could be reached with the tongue. Other areas of the body were cleaned with the feet. The feet were also used to bring the ears down to the mouth so that they could be licked. When the fields were muddy, the hares often stopped other activities, such as feeding, to remove mud that adhered to the feet.

The jack rabbits seemed to rely on hearing more than on any other sense to detect danger. The sense of smell on the other hand seemed to be used for identification of foods; it was also used to detect other jack rabbits. The hares appeared to be able to see movements well, but apparently could not distinguish still objects at any distance.

When danger threatened, the jack rabbits immediately became alert. The first sign of alertness was the raising of the ears in an attentive attitude. If danger seemed remote, they often stood on their hind feet with the front feet held limply in front of them, the ears erect, and the nose vigorously twitching. If one jack rabbit became alerted, the alarm was in some way spread quickly to others in the vicinity. Soon all were alerted. When danger was imminent, the hares reacted either by fleeing or "freezing."

The pattern of the alarm reaction varied according to the type of vegetation in which the hares were located, the activities in which they were engaged, and the suddenness and intensity of the stimulus. When located in dense vegetation, and if the stimulus originated from some distance, the animals tended to sneak away. They ran with the body close to the ground and the ears held low. If suddenly surprised, they frequently reacted by squatting with the head pressed to the ground and the ears lowered on the back, with only the haunches slightly elevated. If the intruder stopped, the rabbits would remain motionless for minutes at a time, apparently watching. When "freezing," they were almost invisible even on relatively bare ground. If the intruder approached more closely, the animals reacted in rapid flight characterized by long leaps, interspersed with an occasional leap higher and longer than the average. While in flight the ears were elevated or only slightly lowered and the tail was lowered rather than elevated in the normal position.

Jack rabbits can attain speeds up to 35 miles an hour or more. One hare was followed on the road with an automobile for about one-half mile at a speed of approximately 35 miles per hour for the entire distance. When in flight, the hares often ran into obstacles, including other hares, ring-necked pheasants and coots. Fences apparently go unnoticed at such times and they often run directly into them. Occasionally, they run into a fence again and again. Several animals were killed by such collisions with fences. Hares in flight never attempted to jump fences.

The jack rabbits on Gray Lodge swim rapidly and well. When pressed, they took readily to the water even in steep-sided ditches. If they were in the water for a short time, such as that required to cross an irrigation ditch, they would shake themselves on emerging. Brief immersion apparently does not wet to the skin. Although the hares readily took to the water when alarmed, they ordinarily seemed to avoid it. However, on several occasions, hares were noted feeding on young green rice and millet flooded to a depth of about two inches. Once an animal was observed to swim a ditch even though it was apparently not pressed. This animal was seen loping across a dried pond area. When it came to the ditch, it hesitated, sat on its haunches, and gazed up and down the ditch as if searching for a route across. The hares then jumped into the water, swam quickly to the other side, and continued on its way. Other jack rabbits have been seen

to run along a steep-sided ditch and then to cross it by using a foot bridge constructed for hunters.

In their ordinary travels the jack rabbits made use of conspicuous trails through the vegetation. These trails were in the denser vegetation, or at times on rather bare ground. The jack rabbits seemed to prefer the easiest route. Thus, when vegetation had been broken down by former movements, the hares continued to use these routes and soon definite trails developed. For example, in one of the fields a tractor came through a dense stand of yellow star thistle breaking two paths. The jack rabbits were quick to make use of these tracks as access routes from the cover of the thistles to more open feeding areas. Within a few weeks definite trails were established in the tracks.

Jack rabbits were frequently noted standing erect on their hind feet and vigorously striking the air with the forefeet in an alternate motion. The significance of this behavior is not understood. Severaid (1942) reported a similar behavior for the snowshoe hare.

The jack rabbits ordinarily were very silent animals. When they were cornered, injured, or handled, however, they frequently emitted a piercing cry. Some of the handled animals responded more aggressively and emitted a guttural growl or grunt. This same low growl or grunt was sometimes heard from females reacting aggressively toward approaching males.

SEXUAL AND AGGRESSIVE BEHAVIOR

The marking of individuals aided observations of behavior because the sex of any marked animal was readily told by noting which ear was tagged.

It was difficult to discriminate between sexual and aggressive behavior. The behavior described below includes both types. They are distinguished here only for the convenience of discussion.

SEXUAL BEHAVIOR

The sexual hunt was observed only in males. It consisted of a random running by the male with its nose near the ground. The trail systems were generally followed, but occasionally, the male left these and covered a home range area of about 35 acres. The running activity was frequently interrupted with brief pauses to sniff at bushes, stones, posts, etc. One animal was observed for slightly more than one hour. During that period it covered an area of about 30 to 35 acres. It investigated many clumps of bushes and every hare that was encountered. It appears that the scent from the anal glands of the jack rabbits aids hunting animals in locating and possibly identifying other hares.

When a sexually excited male encountered another jack rabbit, it made a cautious approach. The approach was accompanied by sniffing; the head was extended and the ears erect. The reactions which

followed varied greatly, depending upon the sex and disposition of the jack rabbit being approached. If the latter was a male, it usually reacted in the same manner as the approacher, leaving its ears erect, stretching its neck and sniffing. Usually such approaches resulted in each animal sniffing at the other and then separating. Occasionally, one was chased off by a short aggressive charge by the other and each resumed the hunt. *Yellow K* (a male) and an unmarked male, which was readily identified by a torn ear, had overlapping home ranges. Contacts between the two often occurred during their hunts, but they were never seen to fight. Sometimes *K* would chase off the other male and vice-versa. They never ran far. In general, each seemed more or less tolerant of the other.

If the approached animal was a female, a very different type of reaction occurred. The female lowered its ears and came about to face the intruder with a menacing attitude. If the male insisted on approaching closer, it was usually met by one or two types of reaction, depending on the swiftness and determination of its approach. If the male approached slowly, and in a hesitant manner, the female often jumped at it and struck it on the head with her front feet. The male usually retreated a short distance after this attack and went about other business. If the male was persistent and pressed the approach, the female frequently jumped straight up in the air and the male charged under her. Upon alighting the female turned quickly about to re-face the male and the sequence was repeated. Sometimes it was the male which leaped into the air and the female charged under him. Twice during such exchanges, the male was noticed to discharge a stream of urine while in the air. This "eurination" (Southern, 1948), may occur more frequently, but it is difficult to detect unless the lighting conditions are favorable. If the initial approach of the male was sudden or violent, the jumping reactions sometimes occurred without the charge of the female.

The entire reaction occasionally ended by withdrawal of the rebuffed male while the female resumed her previous activity. If, on the other hand, the female was forced to retreat, the male followed in hot pursuit in a "sexual chase." The chase was characterized by rapid running in an irregular zig-zag pattern with the male pursuing the female. At times he would catch her and attempt to mount. These attempts were sometimes successful only in that he managed to scratch some fur from her back, but sometimes he would "bowl her over." If the latter occurred, there was usually a wild scramble and both animals came up fighting.

During the chase the pair often passed other jack rabbits which were engaged in various activities. Many of these seemed caught up in the excitement and joined in the chase. Thus, at times, there were groups of six or seven jack rabbits running about in a zig-zag pattern as if playing "follow the leader." Females occasionally joined in these chases. A marked female was observed to join a chase and become the one to be chased.

The chased female might fight one or more of the chasers. If she was successful in warding off one of them in a fight, the others were easily rebuffed by a simple charge and a menacing attitude.

The fights consisted of the male and female leaping into the air and striking each other with their front feet. It was difficult to determine if the hind feet were also used in the air. The two contestants did not always leap up, but sometimes stood on their hind feet and sparred with the front feet. There can be no doubt that this behavior is a fight behavior; fur was seen floating in the air during such matches. Although biting was never noticed, it probably occurred; the contestants were often seen spitting fur from their mouths after the fights. The victor in these boxing matches varied with the situation and the animals involved. If the male won, the chase was usually resumed. If the female won, the male went off in some other direction while she groomed herself or began to feed or drink.

Boxing matches sometimes occurred without the preliminary chase. This was uncommon, however, for the female always tried to escape before she would battle so fiercely.

Copulation may occur following chases and boxing matches. Two successful copulations and one unsuccessful attempt were seen during the entire study. Unfortunately, the reactions preceding these copulations were not observed. The following detailed description of one copulation is, in general, descriptive of the other. Two jack rabbits were first seen when they came running out of weeds, the male chasing the female. When the male caught the female, a short boxing match ensued in which few blows were struck. The female hopped off about two or three yards and started to feed while the male watched. After a few seconds, he came up behind her and mounted her, placing his forefeet on her flanks. The female responded by elevating her hind quarters and lowering her ears and head. Copulation lasted but a few seconds and was characterized by rapid vibrations of the male's hind quarters. At ejaculation the male jumped backward and the female moved away. She stopped about three yards distant and the male approached her again. The female turned to face him in a menacing manner. The male was persistent and she ran off into the weeds with him in pursuit. The act of copulation seen here is similar to that reported for the wild European rabbit (Rowley and Mollison, 1955) and for the snowshoe hare (Severaid, 1942).

SUBSTITUTE OR DISPLACEMENT BEHAVIOR

The behavior patterns described above sometimes ended very suddenly. Thus, if an approach was started and another jack rabbit appeared on the scene, it sometimes caused all hares to start feeding. A chase often stopped in less than a few seconds without a terminal boxing match and all animals began other activities. It was impossible to detect the causes of these sudden changes of behavior every time. In any instance where the behavior was interrupted for one

cause or another, the jack rabbits began a different activity almost immediately. Such activities seemed to replace those which were not completed. Feeding was one of the most common substitute activities. Thus, if a male was rebuffed by a female, he sometimes began to nibble on a nearby plant. The substitute activity was often short lived and the approach was attempted again. These repeated approaches were usually met by the same threatening attitude by the female. Sometimes they were successful in that the female finally ran off and a chase occurred. On several occasions rebuffed males were observed to run off a short distance and dig in the dirt with their front feet. They then rolled in the disturbed earth, lay on their sides and sniffed at the ground. Several of these digging and rolling sequences were noted at the same place. It is possible that there are special spots which are used for this activity. More observations are needed to verify this assumption.

AGGRESSIVE BEHAVIOR

As mentioned before, it is impossible to differentiate completely between sexual actions and those of an aggressive nature.

Male jack rabbits engaged in sexual hunts sometimes went out of their way to chase off other males. These aggressive chases were very short. No boxing match was ever seen following one of them. They were characterized by a charge by one animal and a rapid retreat by the other. They seemed to occur most frequently with animals whose ranges did not normally overlap and during periods when males were actively "hunting." During evening and morning feeding periods, male jack rabbits seemed tolerant of any others which entered their range.

One example of this type of behavior should be mentioned. Males *yellow K* and *yellow B* had ranges which normally overlapped and were frequently seen to meet on "sexual hunts." Seldom was any aggressive reaction noted between the two. On the other hand, *yellow S*, another male, was never seen under ordinary circumstances within the known range of *yellow K*. On one occasion I chased *yellow S* into the hunting area of *K* while the latter was active. K came from a disance of at least 30 yards to rush at *S* and drive it off. *S* responded by quickly running back toward the spot from which I had chased it. More observations on marked animals are necessary to elucidate the factors underlying such aggressive reactions. It appears that jack rabbits may recognize certain of their fellows and allow them within the hunting area, while others are resented and chased from it.

Once a jack rabbit was observed to approach another which was hiding in a clump of weeds. It sniffed at the hidden hare and then attacked the latter so vigorously that fur was torn loose in bunches. The attacker was driven off by the observer and the victim was captured and examined. The hare's hind leg had been broken previously. Hunters have reported instances of one jack rabbit attacking

another which had been wounded. This may have been a similar event.

Female jack rabbits seem to resent the approach of other hares during the height of the breeding season. They have been observed to charge other jack rabbits which approached within five or ten yards of their position. From January to August a majority of the females in the Gray Lodge population are pregnant at one time or another. The charging reaction is more or less universal during these months. Perhaps only pregnant females exhibit this type of behavior. Further study is necessary to clarify this point. The charging behavior no doubt results in spacing the animals, and may be a type of territorial behavior.

SEASONAL INCIDENCE OF BEHAVIOR

All of the sexual and aggressive behavior mentioned above was more or less confined to the breeding season which in this population began in January and extended to August. The reactions reached a peak by early February and then continued on a plateau until late summer or early fall. At this time sexual activity practically ceased. During the months of September, October, November, and early December the jack rabbits on Gray Lodge Waterfowl Area lived in almost complete obliviousness of each other. Only occasional acts of a sexual or aggressive nature were noted.

It is apparent that by very careful observations of behavior, the beginning and end of the breeding season could be accurately determined. As the breeding season approached, there was a decided increase in mid-day activity of the animals. This was soon followed by scattered incidences of sexual hunts, chases and boxing matches. These increased in frequency as more animals began to breed. There was an increase in the number of tufts of hair found lying about in the fields, since many of these tufts are torn from the jack rabbits during the chases and boxing matches. The mid-day activities continued at a high level until all mid-day activity was modified by the heat of summer. Morning and evening observations showed that sexual activities had not ceased at this time, but had been shifted toward the cooler periods of the day. Especially conspicuous were the antagonistic reactions of the females. It was this type of reaction which continued the longest, remaining at a high frequency about one month or more after other sexual and aggressive behavior had ceased. The lack of antagonism among groups of jack rabbits appears to be an almost certain indication that pregnant females are no longer present and breeding has ceased.

SUMMARY

Observations were made on a population of black-tailed jack rabbits on the Gray Lodge Waterfowl Management Area, Butte County, California, over an 18-month period. Approximately 100 of the hares were captured and marked with plastic ear discs, and released.

No social organization or family structure could be detected among the adult hares.

Jack rabbits prefer rather open areas with a good supply of small succulent plants for feeding. The height of feeding activity occurs in the evening, but (depending upon the time of year and the weather) jack rabbits may feed at any time. Jack rabbits construct forms in which they rest. The pattern of use and construction of these is variable.

The hares may react to alarm by freezing, creeping away or fleeing rapidly. The particular reaction apparently depends on the type and suddenness of the alarm, and on the situation in which the hares are located. The alarm appears to spread from one hare to others in the group.

Jack rabbits swim readily and well if pressed. Under ordinary circumstances they seem to avoid water.

Sexual activities can be classified into the following categories: the hunt, the approach, the chase, the boxing match, and copulation. Any or all of these activities can end quickly and be replaced by some other behavior.

Pregnant female jack rabbits avoid approach by others and react in a rather antagonistic manner. This antagonism seems to lead to a spacing of hares and may be considered a type of territorial behavior.

Almost all of the sexual and aggressive behavior appears to be intimately related to the breeding season. The lack of antagonism between jack rabbits appears indicative of the lack of reproductive activity in the population.

REFERENCES

ARNOLD, J. T. 1942—Forage consumption and preferences of experimentally fed Arizona and antelope jack rabbits. Univ. Arizona, Agric. Exp. Sta. Tech. Bull. No. 98:1-86.

HASKELL, H. S., AND H. G. REYNOLDS 1947—Growth, developmental food requirements and breeding activity of the California jack rabbit. Jour. Mamm. 28:129-136.

HENRY, W. V. 1942—Studies on the mobility of the white-tailed jack rabbit *Lepus townsendii companius* Hollister. Unpublished master's thesis, Iowa State College, Ames. 43 pp.

LECHLEITNER, R. R. 1956—The black-tailed jack rabbit on the Gray Lodge Waterfowl Area, California. Unpublished. Ph.D. Thesis, Univ. Calif., Berkeley. 161 pp.

ROWLEY, I., AND B. C. MOLLISON 1955—Copulation in the wild rabbit, *Oryctolagus cuniculus*. Behaviour 8:81-84.

SEVERAID, J. H. 1942—The snowshoe hare: Its life history and artificial propagation. Maine Dept. Inland Fisheries and Game, Augusta, Maine. 95 pp.

SOUTHERN, H. N. 1948—Sexual and aggressive behaviour in the wild rabbit. Behaviour, 1:173-194.

VORHIES, C. T., AND W. P. TAYLOR 1933—The life histories and ecology of jack rabbits, *Lepus alleni* and *Lepus californicus* ssp., in relation to grazing in Arizona. Univ. Arizona, Agric. Exp. Sta. Tech. Bull. No. 49:471-587.

Sperm Transfer in the Water-Mite Hydryphantes ruber Geer

RODGER MITCHELL
Biology Department, University of Florida

There is a rapidly expanding list of mites in which males deposit sperm with little or no regard as to the presence of the female, and females pick up sperm if they encounter a spermatophore in their normal movements (Pauly, 1952; Andre, 1953; Lipovsky, *et al.*, 1957). This represents the first record of spermatophore deposition unaccompanied by pairing behavior in one of the water-mites. *Arrenurus* deposits spermatophores but only as a part of a complicated pairing behavior that guides the female to the spermatophore (Lundblad, 1930). In view of the bewildering diversity of pairing behavior and sperm transfer mechanisms in water-mites (Viets, 1914; Motas, 1928; Lundblad, 1929; Stout, 1953) it appears significant to find a very simple type of sperm transfer in a primitive water-mite, even if ignorance of phylogeny as well as comparative pairing behavior makes the proposal of evolutionary sequences presumptuous at this time.

Members of the genus *Hydryphantes* are among the commonest of the bright red mites found in warm shallow waters of the northern hemisphere; the particular species observed, *Hydryphantes ruber* (Geer), is an actively swimming mite found in vernal ponds of the northern hemisphere. Unlike many swimming forms, the species is, at times, a crawler in moss at or near the water line on floating logs and tree-trunks where great aggregations of nymphs and young adults are commonly observed early in the season. Observations were made on young males (which can be distinguished reasonably well by their smaller size and brighter color) collected from such aggregations of *H. ruber* during late March of 1957 in the vicinity of Burlington, Vermont, as a part of research programs carried out at the University of Vermont.

As soon as exposed to the higher temperatures in the laboratory, males isolated in tap water, or in mass cultures, deposited spermatophores some 4 to 5 μ in diameter on stalks 40 to 50 μ tall. In either situation undisturbed males deposited a series of spermatophores in a line as indicated in Fig. 1a. Males depositing spermatophores crawled slowly over the substrate, or along a stem. As the animal slowly moved forward, the body was raised and lowered at something just under one second intervals. Every time the body was lowered the distended anterior part of the gonopore would touch the substrate and attach or press the base of the spermatophore to the substrate. As the body was elevated the stalk was drawn out of the gonopore. About halfway through the elevation of the body, there was a sudden forcing out of the membranous lips of the gonopore which expelled

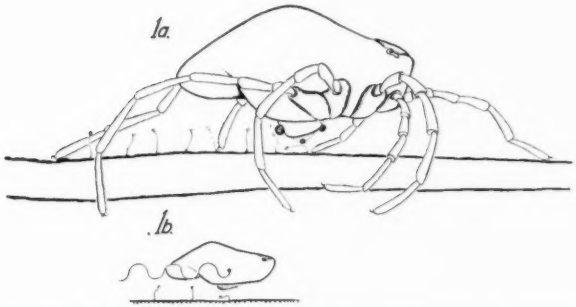


Fig. 1—a.—Male *Hydryphantes ruber* at the moment of expulsion of a spermatophore. b.—Diagrammatic illustration to show the body movements (undulating line) relative to the substrate during deposition of spermatophores. The spermatophores are more widely spaced than normal for purposes of illustration.

with considerable force the remaining half of the stalk and the head of the spermatophore. The exact moment of expulsion is illustrated in Figure 1a.

The body is then elevated to its normal level and the new cycle commences. A row of ten spermatophores was the most ever deposited without some disturbance disrupting the individual. Spermatophores did not hold up well: within ten minutes the head turned from a granular to a clear appearance followed by a breakdown of the external membrane of the spermatophore head.

Live sperm — tiny round objects with long tails but no other discernable morphology — were observed after breaking the spermatophore but the operations in obtaining temporary slide preparations were so difficult to carry out that systematic observations could not be made.

Females were not observed picking up the spermatophores. Andre (1953) and Lipovsky, *et al.* (1957), indicate it to be a simple process of the female grasping and taking the head of the spermatophore with the lips of her gonopore.

Hydryphantes aggregations are conspicuous early in the season. Both the short life of the spermatophore and the lack of interaction between sexes would favor tactic responses that would result in local aggregations where encounters of females with viable sperm would be more probable. Such responses are all the more important in a swimming form such as *Hydryphantes* that does not normally locomote in contact with the substrate.

REFERENCES

ANDRE, M. 1953—Observationes sur la fécondation chez *Allothrombium fuliginosum* Herm. Bull. Mus. Nat. d'Hist. Nat. (2) 25:382-386.

LIPOVSKY, L. J., BYERS, G. W., AND E. H. KARDOS 1957—Spermatophores—the mode of insemination of chiggers (Acarina: Trombiculidae). Journ. Parasit. 43:256-262.

LUNDBLAD, O. 1929—Einiges über die Kopulation bei *Aturus scaber* und *Midea orbiculata*. Zeitschr. Morph. Okol. Tiere 15:474-480.

———1930—Über den Begattungsvorgang bei einigen *Arrenurus*-arten. Zeitschr. Morph. Okol. Tiere 15:705-722.

MOTAS, C. 1928—Contribution à la Connaissance des Hydracariens français particulièrment du Sud-Est de la France. Travaux Lab. Hydrobiol. Pisc., Univ. Grenoble, 20:1-373.

PAULY, FRANZ 1952—Die Copula der Oribaten (Moosmilben). Naturwiss. 39:572-573.

STOUT, V. 1953—*Eylais waikawae*, n. sp. (Hydracarina) and some features of its life history and anatomy. Trans. Roy. Soc. New Zealand, 81:389-416.

VIETS, KARL 1914—Über die Begattungsvorgänge bei *Acercus*-arten. Intern Rev. Hydrobiol. Hydrograph., Biol. Suppl. 6:1-10.

Stoneflies of the Genus Anacroneuria from Mexico and Central America (Plecoptera)

STANLEY G. JEWETT, JR.
Portland, Oregon

The genus *Anacroneuria* Klapálek (1909) is the dominant element in the stonefly fauna of Mexico, Central America, and much of South America. The genus contains many described species most of which have been characterized inadequately for positive identification. The purpose of this paper is to define the 19 species of *Anacroneuria* which I recognize in material from Mexico and Central America.

The nucleus of the material upon which this paper is based is a series of stoneflies collected mostly by the late Alfonso Dampf in Mexico during the early 1930's. Originally sent to Cornell, the specimens passed from Dr. Peter Claassen to Dr. T. H. Frison at Urbana, and then to Dr. Wm. E. Ricker of the Fisheries Research Board of Canada who made a preliminary study of them before sending the collection to me.

The genus *Anacroneuria* was well characterized by Needham and Broughton who stated that the following three characters were typical of the genus: two ocelli; the sinuate course of the second anal vein, at first approximated to the first anal, then diverging from it and thereafter pectinately branched and not connected with the third anal by a cross vein; the basal cubito-anal vein in the forewing, when developed, is situated well beyond the anal cell. It may be mentioned that in addition to these three characters, the male ninth sternite usually bears a small conical nail or hammer and the female subgenital plate is large and has a median notch and sometimes lateral notches.

A number of generic names have been given to tropical American stoneflies with two ocelli. Additional study is required to learn if more than one generic name is needed for them. One of these, *Forquilla* Navas (1924) is represented among material studied from Costa Rica, the locality from which Navas' material came. His descriptions as well as a study of the material at hand convince me that I am justified in placing *Forquilla* as a synonym of *Anacroneuria*.

Older authors placed much weight on venation for differentiating species of *Anacroneuria,* but this character proves to be of minor importance. The male genitalia present a rather uniform aspect, and I have been unable to find characters in the aedeagus for separating the species. The nail of the ninth sternite is totally absent in three of the species studied. Color of the head and pronotum, while showing much intraspecific variation, offers good differentiating characters; the same may be said of the color of the legs, and to a lesser extent, of the wings. The female genitalia, especially the outer margin of the subgenital plate and the sclerotization and chaetotaxy of the ninth

sternite, offer the best specific characters when correlated with color of the head and pronotum. The size of many of the species is quite variable but may be used as a general criterion. The tails may be annulate or not, and it is my opinion that annulate tails may or may not occur in several species depending on the degree of pigmentation of individual specimens. The shape of the pronotum was considered important in earlier descriptions, but this varies with the age of the specimen and with the method of preservation: teneral specimens usually have a quadrate pronotum which becomes narrowed posteriorly after the integument hardens and the postero-lateral margins contract downward and inward.

At least 25 names have been given to species of *Anacroneuria* from Mexico and Central America, very few of which can be recognized from published descriptions. Because of the difficulty of personally studying types, if indeed most of those of earlier authors are actually still in existence, several species are being described as new that may have been characterized at an earlier date. However, care is being taken that other workers can recognize the species to which new names are applied. The key and the descriptions, augmented by the illustrations, should enable allocation of additional material of the species treated, particularly if it has been preserved fresh in 70 to 80 percent ethyl or isopropyl alcohol. Males can frequently best be identified by comparing the head, pronotal, leg, and wing colors with those of associated females.

Preceding the key is a brief description of each species which covers a number of identical items. A pronotum "normal in size and shape" indicates that the pronotum is generally rectangular with the sides narrowing posteriorly; "male normal" means that there is a well developed nail or hammer on the ninth sternite. Drawings of female genitalia have been made from cleared material and are somewhat flattened; the shape of the lobes on the ninth sternite may appear quite differently in uncleared specimens (Figs. 10 and 10A). Abbreviations include the following: AMNH, American Museum of Natural History; CAS, California Academy of Sciences; CNHM, Chicago Natural History Museum; CU, Cornell University; ENCB, Escuela National de Ciencias Biologicas; INHM, Illinois Natural History Survey; USNM, United States National Museum; WER, Wm. E. Ricker; and SGJ, JR, the writer.

Acknowledgment.—I am indebted to Dr. Ricker not only for sending these specimens but also for generously providing his notes from a study of this material. Dr. Henry Dietrich kindly made a search of the Cornell University collection for the specimens of *Anacroneuria* which formed the basis for a paper published by Needham and Broughton (1927). Specimens loaned from this collection included the complete holotypes of three of the four Needham and Broughton species, the mounted wings only of the holotype of *A. coronata,* and the mounted wings of most, if not all, of the other material studied by these authors. Dr. Mont Cazier of the American Museum of Natural History, Dr. J. F. Gates Clarke of the United States National Museum, Dr. Edward S. Ross

of the California Academy of Sciences, Dr. H. H. Ross of the Illinois Natural History Survey, and Dr. Rupert L. Wenzel of the Chicago Natural History Museum very kindly loaned material from the collections under their care.

ANACRONEURIA AETHIOPS (Walker)

1852. *Perla aethiops* Walker, Cat. spec. neurop. insects in coll. Brit. Mus. Part I (Phryganides-Perlides), p. 154.
1861. *Perla aethiops* Hagen, Synop. Neuroptera N.A., Smith. Instit., p. 24.
1927. *Anacroneuria aethiops* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:116, Fig. of ♀ gen.

Length of forewing, 15 mm in female (one specimen). Head brown, tubercles and M-line lighter than rest of head. Pronotum brown; normal in size and shape. Legs brown and yellow, the colored areas squarely delimited; basal two thirds of femora yellow, brown beyond. Tails brown. Wings dark brown.

Female.—Subgenital plate slightly sinuate with a broad, U-shaped notch on hind margin. Ninth sternite with sclerotized area beset with close-set spinules and with lightly sclerotized median tail or stem.

Male.—No material at hand.

The specimen examined is smaller than two described by Needham and Broughton which had forewing measurements of 18 and 20 mm. The brown head, pronotum, and wings and the sharply bicolored legs characterize this species. The female subgenital plate is distinctive.

Collection Data.—MEXICO. Oaxaca: Yagalexi, 2-II-32, A. Dampf, ♀ (ENCB).

Anacroneuria flavifacies n. sp.
Fig. 1

Length of forewing, 18 mm in male (one specimen). Head yellow anterior to ocelli, dark brown at sides and rear. Pronotum dark brown, normal in size and shape. Legs dark brown. Tails brown. Wings dark brown.

Female.—Unknown.

Male.—Normal.

The color pattern of the head and pronotum is quite unlike that of any other known species from the region covered.

Collection Data.—HOLOTYPE male, Temescaltepec, Real de Arriba, MEXICO, 4-VI-33, H. E. Hinton & R. L. Usinger (CAS).

Anacroneuria pallida n. sp.
Fig. 2

Length of forewing, 22-25 mm in female. Head yellow in alcohol. Pronotum yellow, normal in size and shape. Legs yellow to light brownish yellow distally. Tails yellow to brownish yellow. Wings yellow, veins yellow brown.

Female.—Subgenital plate with a broad, V-shaped median notch and a suggestion of lateral notches on either side. Ninth sternite with a sclerotized area comprising two rectangular lobes distally which are separated by a large, V-shaped, unsclerotized area, the sclerotized lobes beset with coarse hairs or spinules, and a light median stem basally that is not clothed with hairs.

Male.—Unknown.

This species is characterized by the pale color throughout; possibly in life it is greenish in color. The female subgenital plate is very distinctive though similar to that of *A. naomi.*

Collection Data.—HOLOTYPE female and PARATYPE female, Yepocapa, Mun. Yepocapa, Chimaltenango, el. 4,800 ft., GUATEMALA, at light, 12-V-48, R. L. Wenzel (holotype, CNHM, paratype, SGJ, JR). Additional PARATYPES as follows: GUATEMALA. Same place as holotype, 15-V-48, R. L. Wenzel, ♀ (USNM); Santa Clara, in interior valley of Sierra de las Minas, N. of Cabanas, Zacapa, el. 5,500 ft., 8-VIII-48, R. D. Mitchell, ♀ (CNHM). MEXICO. Chiapas: Rio Blanco, 17-VIII-35, ♀ (ENCB).

ANACRONEURIA NAOMI Needham and Broughton

1927. *Anacroneuria naomi* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:115-116, figs. of wings and ♀ gen.

Lenth of forewing, 22 mm in female (holotype). Head dark brown with lighter M-line. Pronotum pale (in alcohol), half wider than long. Legs dark brown and yellow, the colors sharply delimited, basal two thirds of hind femora yellow, rest of leg dark brown. Tails brown. Wings brown.

Female.—Border of subgenital plate sinuate with a U-shaped notch (not a V-shaped notch as shown by Needham and Broughton). Ninth sternite similar to that of *A. pallida;* it has a V-shaped, median, unsclerotized area distally separating two truncate arms of a sclerotized area beset with coarse hairs, and basally there is a median, lightly-pigmented, sclerotized stem.

The head and pronotal colors are distinctive for this species. A male specimen tentatively placed in this species had an orange pronotum before it was relaxed and placed in alcohol. The brown head has a squarish, almost black area between and to the rear of the ocelli. The wings are fumose, the legs colored as in the female holotype. It has a well developed nail or hammer on the ninth sternite.

Collection Data.—"Senahu, Vera Paz, Champion," HOLOTYPE female (CU). Identification not certain: GUATEMALA. Alta Vera Paz, Cacao Trece Aguas, Swarz & Barber, ♂ (USNM).

Anacroneuria magnirufa n. sp.
Figs. 3, 3A

Length of forewing, 20 mm in male (two specimens), 25 mm in female (one specimen). Head brown with a darker brown mark

extending from behind the ocelli forward to the ocellar area and laterally to the eyes. Pronotum brown with a central dark brown stripe divided by a fine yellow line; normal in size and shape. Legs brown and yellow, the areas sharply delimited in the two available males, less so in the single available female. Tails annulate. Wings dark brown in female specimen, light brown in the males.

Female.—Border of subgenital plate slightly sinuate with a median, small, U-shaped notch. Ninth sternite of female with a broad, T-shaped, sclerotized area beset anteriorly with spinules.

Male.—Ninth sternite lacks the usual hammer.

This species is very much like *A. cincta* in appearance, but the pronotal color pattern is different, and the female subgenital plates of the two species have notches quite different in shape.

Collection Data.—HOLOTYPE female, El Volcan, Chiriqui, PANAMA, 26-II-36, Gertsch & Lutz (AMNH). ALLOTYPE male, and PARATYPE male, HONDURAS, 1940, W. von Hagen (Allotype, AMNH, paratype, SGJ, JR).

Anacroneuria nigrolineata n. sp.
Figs. 4, 4A

Length of forewing, 14-15 mm in female (two specimens). Head yellow with a squarish black spot including the ocelli and forward to the M-line, beyond which is a light brown, tongue-shaped spot. Sides and median stripe of pronotum solid dark brown, the inner lateral yellow stripes rather narrow, normal in size and shape. Legs sharply marked in brown and yellow, the front femora nearly all brown above, the middle ones about two thirds brown, the hind ones only about one quarter brown. Tails yellow brown. Wings dark brown.

Female.—Subgenital plate with a median, rather deep, U-shaped notch. Ninth sternite apparently without sclerotized area or spinules.

Male.—Unknown.

The head and pronotal color pattern, together with the shape of the female subgenital plate, separate this species.

Collection Data.—HOLOTYPE female and PARATYPE female, MEXICO (holotype, INHS, paratype, SGJ, JR).

ANACRONEURIA SULANA Needham and Broughton

1927. *Anacroneuria sulana* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:112-113, figs. of ♀ gen.

Length of forewing, 14-16 mm in male, 18-20 mm in female. Head brown around ocelli and forward to M-line, and in front of the M-line in a large, bell-shaped spot, yellowish rearward. Sides, front and hind margins, and middle stripe of pronotum brown; stripe may have a fine yellow midline; sides between lateral and median stripe yellow; size and shape normal except that posterior border is usually markedly recessed; color usually more striking than in *A. nigrocincta.* Legs

brown and yellow, the color areas not sharply delimited; femora two-thirds dark on forelegs, half dark on middle and hind legs. Tails brown. Wings hyaline, tinged with light brown.

Female.—Subgenital plate four-lobed, the smaller, inner pair distinctive (Fig. 2 of Needham and Broughton, 1927). The sclerotized area of the ninth sternite T-shaped, the spinules longest toward the outer border anteriorly; median anterior area without hairs (Fig. 2A of Needham and Broughton, 1927).

Male.—Normal.

The colors of this species usually more distinctive, more contrasting than those of *A. nigrocincta;* the head color pattern seems to be specific. The subgenital plate of the female is distinctive. Males are sometimes difficult to separate from those of *A. nigrocincta.*

Collection Data.—MEXICO. Hidalgo: Mixquihuala, 17-VI-34, A. Dampf, 2 ♀ (ENCB, SGJ, JR). Nuevo Leon: Hacienda Vista Hermosa, Villa de Santiago, alt. 2,500 ft., 9-VIII-39, R. Haag, ♀ (CNHM). Oaxaca: Valle National, 2-III-32, A. Dampf, ♀ (INHS). No other locality, 4♂, 2♀ (ENCB). GUATEMALA, Alta Vera Paz: Lanquin, 8-VI-48, at light, R. D. Mitchell, 16♀ (CNHM, WER, INHS, SGJ, JR); Cacao Trece Aguas, Schwarz & Barber, ♀ (USNM). PANAMA. El Volcan, Chiriqui, 20-II-36, Gertsch & Lutz, ♀ (AMNH); same except 26-II-36, ♀ (SGJ, JR); same except 1-III-36, ♂ (AMNH).

ANACRONEURIA NIGROCINCTA (Pictet)

1842. *Perla nigrocincta* Pictet, Hist. nat. gén. et part. des insectes Névroptères. Fam. de Perlidae, p. 236, fig. of adult.
1852. *Perla nigrocincta* Walker, Cat. spec. neurop. insects in coll. Brit. Mus. Part I (Phryganides-Perlides), p. 158.
1861. *Perla nigrocincta* Hagen, Syn. Neuroptera N.A., Smith. Inst., p. 24.
1927. *Anacroneuria nigrocincta* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:113, figs. of ♀ gen.

Length of forewing, 10-14 mm in male, 15-20 mm in female. Head brown from ocelli forward and laterally except M-line; yellow between eyes and ocelli and on rear of head. Sides, front and hind margins of pronotum brown; a narrow, median brown stripe with or without a central yellow line; sides between lateral and median brown areas yellow; hind margin usually straight, not concave. Legs brown and yellow, the femur yellow basally, brown apically, rest of leg brown. Tails usually yellow brown, sometimes with outer segments annulate. Wings hyaline, tinged with light brown.

Female.—Subgenital plate four-lobed, the inner lobes of variable size and distinctness (Figs. 3A, 3B of Needham and Broughton, 1927). Ninth sternite of female with a rounded patch of thick hairs or spinules on the anterior portion of the large T-shaped sclerotized area.

Male.—Difficult to distinguish with certainty from *A. sulana* though color and shape of hind margin of pronotum may serve to separate it; a well developed hammer on the ninth sternite.

The female subgenital plate together with the color of the pronotum distinguish this species in the female. The male may be indistinguishable from the male of *A. sulana*, though the color pattern is often distinctive.

Material provisionally placed in this species from Costa Rica and Panama has the yellow and brown markings strongly contrasting, the outer segments of the tails bicolored. While showing considerable variation, the shape of the female subgenital plate can always be separated from that of *A. sulana*.

Collection Data.—MEXICO. Chiapas: Barranca Honda, 24-II-31, Jose Parra, 3♂, 3♀ (INHS, SGJ, JR); Esmeralda, 18-XI-30, A. Dampf, ♂, 3♀ (ENCB); same except 19-XI-30, 3♀ (INHS, SGJ, JR); El Zapote, 13-XI-30, A. Dampf, 7♂ (ENCB); same except 15-XI-30, ♀ (ENCB); Santa Ana, 25-II-31, Jose Parra, ♂, 6♀ (WER, INHS); Finca Vergel, 23-V-35, A. Dampf, ♂ (INHS); Sta Isabel, 17-XI-30, ♂, ♀ (WER); Liquidambar, 21-III-31, J. Parra, 2♂ (ENCB); no other locality, 6♀, ♂ (ENCB). Guerrero: Tierra Colorado, 18-XII-29, A. Dampf, 13♂, ♀ (ENCB, INHS, SGJ, JR). Hidalgo: Mixquiahuala, 17-VI-34, A. Dampf, ♀ (INHS). Morelos: Amacuzac, 1-VIII-30, Jose Parra, ♀ (ENCB). Oaxaca: Tolosa, 1-I-32, J. Parra, ♀ (ENCB); Valle National, 2-III-32, A. Dampf, 4♀ (SGJ, JR). Puebla: Atencingo, 19-VII-30, A. Dampf, 2♂, 3♀ (ENCB, INHS). Vera Cruz: Jalapa, 22-V-46, J. & D. Pallister, ♂ (AMNH); Atoyac, 14-VII-41, H. S. Dybas, ♂ (CNHM); Cordoba, 25-VII-41, H. S. Dybas, ♀ (CNHM). No other data: 2♂, 4♀ (ENCB). Probably Mexico: 2♂, 6♀ (ENCB). GUATEMALA. Palin, V-24, W. M. Mann, ♂, ♀ (USNM); Alta Vera Paz, Cacao Trece Aguas, Schwarz & Barber, ♀ (USNM); Coatepeque, 22-XI-32, A. Dampf, ♂, ♀ (ENCB). Identification not certain: COSTA RICA. San Pedro de Montes de Oca, 2-II-34, C. H. Ballou, at light, ♀ (USNM). PANAMA. El Volcan, Chiriqui, 1-III-36, Gertsch & Lutz, ♀ (AMNH).

Anacroneuria dampfi n. sp.
Fig. 5

Length of forewing, 11-12 mm in male, 14-15 mm in female. Head brown between and behind ocelli; lappets brown; rest of head yellowish. Pronotum very much like that of *A. nigrocincta* but smaller and more sharply marked; normal in size and shape. Legs brownish yellow. Tails brownish yellow. Wings hyaline, tinged with light brown.

Female.—Subgenital plate with a median V-shaped notch and no lateral notches. The sclerotized area of the ninth sternite T-shaped, the arms bearing patches of modified hairs.

Male.—Normal.

Size, color, and shape of the subgenital plate of the female separate this species. Males must be determined largely by association with females, although the less sharply marked color patterns, especially those of the legs, seem to separate this species from *A. chiapasa*.

Collection Data.—HOLOTYPE female, Finca Vergel, Chiapas, MEXICO, 29-V-35, A. Dampf (INHS); ALLOTYPE male, same locality and collector as

for the holotype, 15-V-35 (INHS). PARATYPES as follows: MEXICO. Same data as for holotype, 2♀ (SGJ, JR, USNM); same locality and collector as for holotype, 11-V-35, ♀ (WER); same except 19-V-35, 2♀ (ENCB, SGJ, JR).

Anacroneuria chiapasa n. sp.
Fig. 6

Length of forewing, 12 mm in male, 14-15 mm in female. Head dark behind ocelli shading to yellow forward and laterally; lappets brown. Pronotum brown on sides with or without an irregular, narrow, outer yellow border; median brown stripe with a fine central yellow line as in *A. nigrocincta;* normal in size and shape. Legs yellow and brown. Tails brownish yellow. Wings hyaline, tinged lightly with brown.

Female.—Subgenital plate with a median U-shaped notch and no lateral notches. The sclerotized area of the ninth sternite T-shaped, similar to that of *A. dampfi* but apparently lacking modified hairs.

Male.—Normal.

The color and shape of the head and pronotum and the shape of the female subgenital plate separate this species. The male allotype is very similar to that of *A. dampfi,* but the legs are more sharply marked.

A number of specimens examined, not definitely placed with this species, may belong here. The males and most of the females have contrasting brown and yellow patterns, especially on the legs. The female genitalia are very close to those of the holotype, but most of the specimens are appreciably larger; one has brown fumose wings. This questionable material is from Mexico, Guatemala, and Costa Rica and is represented by single specimens from widely scattered localities. Until additional, similar material is at hand it seems best not to assign a name to any of these specimens.

Collection Data.—HOLOTYPE female, and ALLOTYPE male, El Zapote, Chiapas, MEXICO, 13-XI-30, A. Dampf (INHS). PARATYPES as follows: MEXICO. Chiapas: Sta Isabel, 16-XI-30, A. Dampf, 2♀ (ENCB, SGJ, JR).

Anacroneuria quadriloba n. sp.
Figs. 7, 7A

Length of forewing, 14-20 mm in male, 19-22 mm in female. Head predominantly yellow with brown ocellar area, the brown pigment diffusing forward and laterally to yellow areas. Pronotum brown on sides with or without an irregular outer yellow band and a broad, median stripe of yellow that occupies half or more of the width of the pronotum; normal in size and shape. Legs yellow and brown, the colors blending; front femur yellow with a small patch of brown distally; a little brown distally on middle femur; hind femur completely yellow; tibiae similarly colored. Tails brownish yellow. Wings hyaline, tinged lightly with brown.

Female.—Subgenital plate four-lobed with a median, rather shallow, U-shaped notch, the inner lobes not prominent. Ninth sternite of female with triangular sclerotized patches beset with spinules on either side of an unsclerotized middle area; very similar to that of *A. pallida.*

Male.—Normal.

The color of head and pronotum and shape of the female subgenital plate characterize this species.

Collection Data.—HOLOTYPE female, and ALLOTYPE male, 8 male and 5 female PARATYPES, Metlac (between Orizaba and Cordoba), Vera Cruz, MEXICO, 26-XII-40, H. H. Hobbs & F. N. Young (holotype and allotype, CNHM, paratypes, WER, SGJ, JR, ENCB). Additional PARATYPES as follows: MEXICO. Chiapas: La Prusia, 25-III-31, J. Parra, ♂ (ENCB); Liquidambar, 21-III-31, A. Dampf, ♂ (ENCB); Barranca Honda, 24-II-31, J. Parra, 6♂ (ENCB, INHS). Vera Cruz: Cordoba, Fred Knab, ♂ (USNM).

Anacroneuria flavominuta n. sp.

Length of forewing, 10-14 mm in male, 12-17 mm in female. Head predominantly yellow throughout, sometimes with light brownish wash anterior to the ocelli. Pronotum yellow in a narrow band along the sides and over most of median area, the yellow central area occupying half or more of the total width of the pronotum; brown in two irregular bands next to the lateral yellow borders; normal in size and shape. Legs mostly yellow with a dark brown dorsal band on the proximal end of the femora. Tails yellow brown. Wings clear, marginal veins yellow, others brown.

Female.—Subgenital plate with a median, U-shaped notch and no lateral notches; very similar to that of *A. chiapasa.* The sclerotized area of the ninth sternite is not distinctly defined and the hairs are little modified.

Male.—Normal.

The wide, yellow, median pronotal band and the shape of the female subgenital plate separate this species. Males cannot always be placed with certainty. There is considerable difference in size in material from different localities, and some specimens are distinctly darker in color than most.

Collection Data.—HOLOTYPE female, and ALLOTYPE male, Santa Ana, Chiapas, MEXICO, 25-II-31, A. Dampf (INHS). PARATYPES as follows: MEXICO. Chiapas: Vergel, 17-V-35, ♀ (WER); same locality except 19-III-31, A. Dampf, ♀ (ENCB); Liquidambar, 19-III-31, J. Parra, ♂ (ENCB); Santa Ana, 25-II-31, Jose Parra, ♀ (INHS); Finca Victoria, 29-V-35, ♀ (ENCB); El Zapote, 13-XI-30, 2♂ ♀ (INHS); Tapachule, V-02, Cook & Collins, ♀ (USNM); no other locality, 14♀ (ENCB, INHS, SGJ, JR, WER). Pueblo: Zacatepec, 28-VI-32, Quiroz, ♀ (ENCB). PANAMA. Cabima, 30-V-11, August Busck, ♂ (USNM); El Volcan, Chiriqui, 21-II-36, ♂, ♀ (AMNH). GUATEMALA. Lanquin, Alta Vera Paz, 8-VI-48, R. D. Mitchell, 5♀ (CNHM, SGJ, JR); Yepocapa, Mun. Yepocapa, Chimaltenango, 15-V-48, R. L. Wenzel, ♀ CNHM); Cayuga, V-1915, Wm. Schaus,

♀ (USNM); Alta Vera Paz, Cacao Trece Aguas, Schwarz & Barber, 3♀ (USNM).

ANACRONEURIA BLANDA Needham and Broughton

1927. *Anacroneuria blanda* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:117, figs. of head and ♀ gen.

Length of forewing, 13 mm in female holotype. Head yellow with a quadrangular black area including the ocelli. Pronotum with yellow lateral borders and a median yellow stripe that occupies about a third of the width of the pronotum; a broad brown stripe on either side of the median yellow stripe. Legs yellow and brown, the yellow on the basal half of the femora and middle of the tibiae, the yellow area more extensive on hind than on forelegs. Tails yellow. Wings smoky hyaline.

Female.—Subgenital plate with a broad V-shaped notch and no lateral notches (Fig. 9A of Needham and Broughton, 1927). Ninth sternite of female with a large, median, rounded sclerotized area, beset with spinules on the distal portion, forming the head of a T-shaped sclerotized area.

Male.—Unknown.

The color pattern of the head combined with the shape of the female subgenital plate differentiates this species.

Collection Data.—Barro Colorado Island, PANAMA, HOLOTYPE female.

Anacroneuria tristani (Navas) n. comb.
Figs. 8, 8A, 8B

1932. *Forquilla tristani* Navas, R. Univ. Torino (Turin), Mus. Zool. e Anat. Compar. Bol. 42, ser. 3, no. 26:29-30, fig. hind wing.

Length of forewing, 15 and 21 mm in male, 17 and 19 mm in female. A dark brown spot or area on head immediately anterior to the ocelli, sometimes extending behind the ocelli, the shape of the area variable; rest of head mostly yellow; lappets dark. Pronotum with brown sides and a median yellow stripe which is a quarter to a third of the total width; shape normal. Legs sharply marked in brown and yellow, the yellow predominating; very similar in color to those of *A. blanda.* Tails yellow brown. Wings hyaline, tinged with brown.

Female.—Subgenital plate with a median, U-shaped notch and no lateral notches. The area of the ninth sternite occupied by modified hairs is roughly T-shaped, the arms forming triangles, the stem rather inconspicuous; similar in appearance to that of *A. blanda.*

Male.—Normal.

The head and pronotal markings, the sharply separated brown and yellow areas of the legs, and the shape of the female subgenital plate separate this species.

The width of the median, yellow pronotal stripe is variable, one

specimen showing invasion of brown pigment almost to the middle of the pronotum at the posterior end of the stripe.

Collection Data.—COSTA RICA. Turrialba, Schild-Burgdorf, ♂, 2♀ (♂, ♀, USNM, ♀, SGJ, JR); Mount Poas, V, Wm. Schaus, ♂ (USNM).

ANACRONEURIA CINCTA (Pictet)

1842. *Perla cincta* Pictet, Hist. nat. gén. et part. des insects Névroptères. Fam. de Perlides, p. 227, fig. of adult.
1852. *Perla cincta* Walker, Cat. spec. neurop. insects in coll. Brit. Mus. Part I. (Phryganides-Perlides), p. 156.
1861. *Perla cincta* Hagen, Syn. Neuroptera N.A., Smith. Instit., p. 24.
1927. *Anacroneuria cincta* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:115, fig. of ♀ gen.

Length of forewing, 17 mm in male, 23 mm in female. Head yellow with prominent dark mark from the median hind part forward through ocellar area and extending almost to the eyes; M-mark yellow or light brown. Pronotum predominantly brown with a very narrow median yellow band; normal in size and shape. Legs predominantly brown dorsally in female; yellow and brown dorsally in male, the first femur with a small median yellow area, second femur with middle half yellow, third femur yellow except for distal third. Tails annulate throughout. Wings hyaline, tinged with brown.

Female.—Subgenital plate of female with a median V-shaped notch (Fig. 4 of Needham and Broughton, 1927). Ninth sternite of female with the sclerotized area beset with spinules and without a median, clear area on hind margin.

Male.—Without a hammer on the ninth sternite.

The head color and female genitalia separate this from the other species treated in this paper. From *A. magnirufa* it differs in the color of the pronotal stripe and in the shape of the notch in the female subgenital plate.

Collection Data.—PANAMA. El Volcan, Chiriqui, 18-II-36, Gertsch & Lutz, ♀ (AMNH); same except 20-II-36, ♂ (AMNH); same except 26-II-36, ♂, ♀ (SGJ, JR).

Anacroneuria hoogstraali n. sp.
Figs. 9, 9A

Length of forewing, 10-11 mm in male, 14-15 mm in female. Head brownish yellow, darker brownish in ocellar area; lappets brown. Pronotum broad, about twice as wide as long; brownish with a narrow, median, yellow stripe that occupies about a sixth of the width. Legs almost wholly brown in male but basally some yellow in female, the yellow most extensive on hind legs. Tails brown. Wings somewhat fuscous brown.

Female.—Subgenital plate of female with a narrow, median, U-shaped notch and no lateral notches. Ninth sternite of female with a

T-shaped, sclerotized area, the arms of the T rather narrow, spinules rather fine.

Male.—Normal.

The color and shape of the pronotum and head together with the shape of the female subgenital plate are sufficient to differentiate this species.

Collection Data.—HOLOTYPE female, and ALLOTYPE male, Galeana, Municipio de Galeana, Nuevo Leon, MEXICO, el. 7,250 ft., 22-VII-38, H. Hoogstraal (CNHM). PARATYPES as follows: MEXICO. Nuevo Leon: same data as for holotype except 2-VIII-38, ♂ (USNM); same data except 8-VII-38, ♂, ♀ (SGJ, JR); Cerro Polosi, el. 8,000 ft., 29-VII-38, H. Hoogstraal, ♂ (CNHM).

ANACRONEURIA DILATICOLLIS (Burmeister)

1839. *Perla dilaticollis* Burmeister, Handbuch der Entomologie, Berlin, p. 880.
1842. *Perla dilaticollis* Pictet, Hist. nat. gén. et part. des insectes Névroptères. Fam. de Perlides, p. 240, fig. of adult.
1852. *Perla dilaticollis* Walker, Cat. neurop. insects in coll. Brit. Mus. Part I (Phryganides-Perlides), p. 158.
1861. *Perla dilaticollis* Hagen, Syn. Neuroptera N.A., Smith Instit., p. 25.
1927. *Anacroneuria dilaticollis* Needham and Broughton, N.Y. Ent. Soc. Jour. 35:117-118, fig. of ♀ gen.

Length of forewing, 8.5-10 mm in male. Head predominantly yellow, ocellar area and tubercles may be brownish. Pronotum with a central yellow stripe that occupies about a quarter of the width of the pronotum; brown stripes either side of the central yellow stripe which may have an irregular yellow border; normal in size and shape. Legs yellow or with a brownish wash especially on upper femora. Tails yellow brown. Wings hyaline with a faint brown tinge.

Female.—Not positively identified.

Male.—Without a hammer on the ninth sternite.

The width of the central yellow stripe on the pronotum and lack of a nail on the ninth sternite distinguish the male of this species. Two female specimens provisionally placed here agree with the males in color pattern of the pronotum. The subgenital plate of these specimens has a narrow, median, U-shaped notch and no lateral notches. The ninth sternite has a T-shaped sclerotized area the arms of which form triangles that are beset with modified, stout hairs, the leg of the T only faintly brown. From the female of *A. flavolineata* these differ in being smaller, and from *A. flavominuta* they differ in the width of the pronotal stripe and in the sclerotization of the ninth sternite.

Burmeister's type of *A. dilaticollis* came from Brazil, and it is quite possible that this name should not be used for Mexican material. I am following Needham and Broughton in using the name for the species described above.

Collection Data.—MEXICO. Chiapas: Esmeralda, 19-XI-30, A. Dampf, 2♂, (ENCB, SGJ, JR). GUATEMALA. Lanquin, Alta Vera Paz, 3-VI-48, 1,000 ft. el., R. D. Mitchell, ♂ (CNHM); Coatepeque, 22-XI-32, A. Dampf,

♂ (SGJ, JR). Identification not certain: MEXICO. Chiapas: Escuintler (?), 11-XI-30, ♀ (ENCB); Huixtla, 21-XI-30, A. Dampf, ♀ (SGJ, JR).

Anacroneuria flavolineata n. sp.

Figs. 10, 10A

Length of forewing, 20-24 mm in female. Head yellow with some faint brown in ocellar area. Pronotum with lateral borders yellow adjacent to irregular brown stripes; central area which occupies almost half of the entire width, yellow; normal in size and shape. Femora mostly yellowish basally grading to light brown on rest of leg. Tails annulate. Wings hyaline, tinged with brown.

Female.—Subgenital plate with a shallow, median, U-shaped notch and no lateral notches. Ninth sternite with the sclerotized area very faintly pigmented, apparently T-shaped; hairs very slightly modified.

Male.—Unknown.

The head and pronotal color pattern together with size and shape of the female subgenital plate distinguish this species. The female subgenital plate and sclerotization of the ninth sternite are similar to those of *A. tristani.*

Collection Data.—HOLOTYPE female, 14 female PARATYPES, Lanquin, el. 1,000 ft., Alta Vera Paz, GUATEMALA, 8-VI-48, at light, R. D. Mitchell (holotype and 6 paratypes, CNHM, paratypes, INHS, SGJ, JR, WER). Additional PARATYPES as follows: GUATEMALA. Same data as for holotype except 5-VI-48, 3♀ (CNHM). MEXICO. Hidalgo: Guerrero Mill, alt. 9,000 ft., Mann & Skewes, 2♀ (USNM). Vera Cruz: Tezonapa, 8-VIII-41, Henry Dybas, ♀ (CNHM); between Orizaba and Cordoba, 26-XII-40, H. H. Hobbs & F. N. Young, ♀ (SGJ, JR).

Anacroneuria crenulata n. sp.

Fig. 11

Length of forewing, 9-10 mm in male, 11-14 mm in female. Head yellow or with some brown in ocellar area and on lappets. Sides of pronotum brown; central yellow stripe, that occupies from a quarter to a half of the total width of the pronotum, with margins regular or irregular; normal in size and shape. Front femora brown, femora of middle leg half brown, femora of hind leg with very little brown; dorsally the distal end of femora with a dark brown area. Tails yellow, outer segments annulate. Wings hyaline with a brown tinge.

Female.—Subgenital plate four-lobed with a rather large U-shaped notch. The T-shaped sclerotized area of the ninth sternite has a bowed top finely beset with spinules.

Male.—Normal.

The size of the median yellow stripe on the pronotum and in the female the shape of the subgenital plate separate this species.

A female from Nuevo Leon has the subcosta-radius area stained

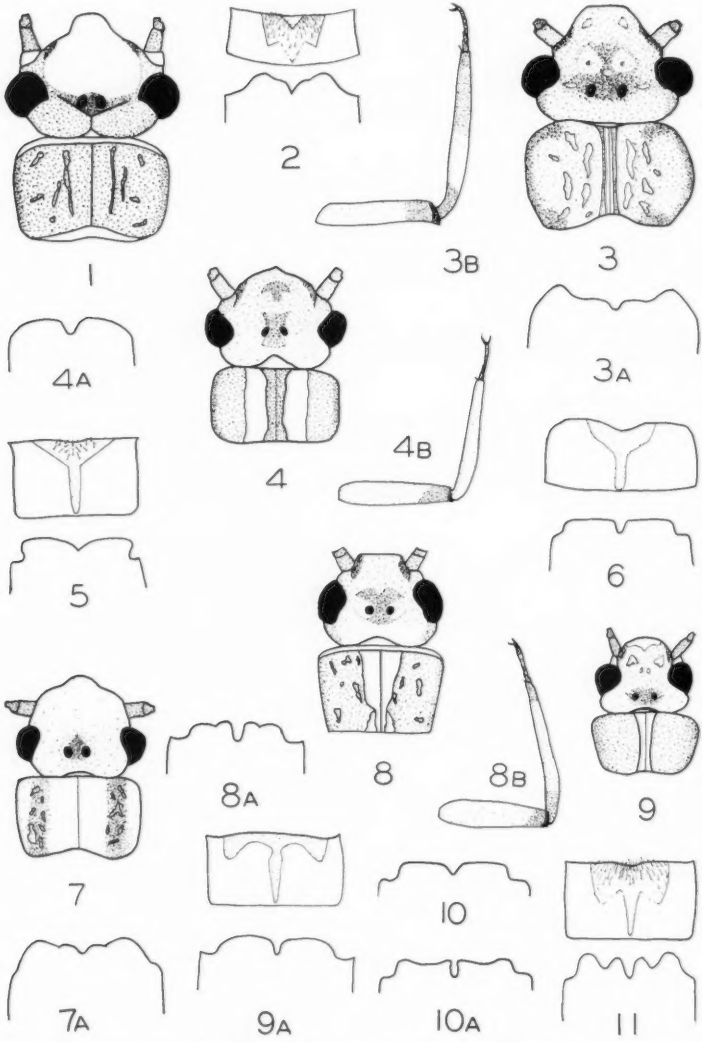


Fig. 1.—*Anacroneuria flavifacies*, head and pronotum of holotype male. 2.—*A. pallida*, 8th and 9th sternites of holotype female. 3.—*A. magnirufa*, head and pronotum of holotype female; 3A, 8th sternite of holotype female; 3B, hind leg of male paratype. 4.—*A. nigrolineata*, head and pronotum of holotype female; 4A, outline of holotype female 8th sternite; 4B, hind leg of paratype female. 5.—*A. dampfi*, 8th and 9th sternite of female. 6.—*A. chiapsa*, 8th and 9th sternites of female. 7.—*A. quadriloba*, head and pronotum; 7A, 8th sternite of female. 8.—*A. tristani*, head and pronotum (pronotal stripe may be aberrant); 8A, 8th sternite of female; 8B, hind leg. 9.—*A. hoogstraali*, head and pronotum of paratype male; 9A, 8th and 9th sternites of holotype female. 10. *A. flavolineata*, 8th sternite of female after treatment in KOH; 10A, untreated female 8th sternite. 11.—*A. crenulata*, 8th and 9th sternites of female.

dark brown, strongly contrasting with the color of the rest of the wing; the head and legs also have dark brown areas.

Collection Data.—HOLOTYPE female, and ALLOTYPE male, Mexcala, Guerrero, MEXICO, 13-XII-29 (INHS). PARATYPES as follows: MEXICO. Guerrero: Balsas R., Balsas, 15-VIII-30, J. Parra, ♀ (SGJ, JR); Balsas, 11-XII-29, A. Dampf, ♂ (SGJ, JR). Chiapas: Sta Isabel, 16-XI-30, A. Dampf, ♂ (ENCB); Finca Vergel, 22-V-35, A. Dampf, ♂ (INHS); no other data, 3♀ (ENCB). Nuevo Leon: Montemorelos, 3-VI-31, A. Dampf, ♀, 2♂ (INHS); 4 mi. W. of El Cercado, 6-VI-51, P. D. Hurd, ♀ (CAS). Morelos: Cuernavaca, 3-VI-28, ♀ (ENCB); Puenta de Ixtla, 24-XII-29, ♀ (INHS); Amacuzac, 1-VIII-30, J. Parra, ♂, ♀ (ENCB). Vera Cruz: Rio Metlac, nr. Fortin, 17-XII-48, H. B. Leach, ♂ (CAS). Pueblo: Atencingo, 19-VII-30, 2♀ (SGJ, JR). Tamaulipas: 9 mi. S. Victoria, 18-V-52, Cazier, Gertsch, Schrammel, ♂ (AMNH). D.F.: Sta. Rosa, nr. Mexico City, 24-I-32, A. Dampf, ♂, 2♀ (SGJ, JR). Tabasco: no other data, ♀ (ENCB). Temescaltepec, 1-2/VI/33, H. E. Hinton, R. L. Usinger, ♂ (CAS). BRITISH HONDURAS. El Cayo, 24-X-29, ♂ (USNM). HONDURAS. VII-1934, ♂ (USNM). PANAMA. El Volcan, Chiriqui, III-1936, ♀ (AMNH); same except 27-II-36, ♀ (SGJ, JR); La Chorrera, 10-12/V, Aug. Busck, ♀ (USNM); same except 12-13/IV, ♀ (USNM); Tabernilla, C.Z., 4-V-07, August Busck, ♂ (USNM).

KEY TO MEXICAN AND CENTRAL AMERICAN SPECIES OF ANACRONEURIA

1 Pronotum evenly colored in yellow, brown, or black 2
Pronotum striped with a pattern of yellow and brown or black 5

2 (1) Pronotum entirely dark brown; wings dark brown 3
Pronotum yellow; wings hyaline or dark brown 4

3 (2) Head uniformly dark brown ..... *aethiops*
Head with a quadrangular yellow area extending from in front of ocelli to anterior margin ..... *flavifacies*

4 (2) Head and pronotum uniformly pale ..... *pallida*
Head black, pronotum orange or yellow ..... *naomi*

5 (1) Median field of pronotum predominantly brown, often divided by a very narrow stripe along the middle groove (Figs. 3 and 4) 6
Median field of pronotum predominantly yellow (Figs. 7, 8, and 9) ..13

6 (5) Color of femora sharply delimited, the brown pigmented areas separated from the yellow at least on the upper surface 7
Color of femora not sharply delimited, brown areas gradually diffusing to yellow areas 9

7 (6) Pronotum with solid dark brown median stripe bordered by yellow stripes; wings heavily infuscated; posterior border of subgenital plate of female straight with a deep, U-shaped notch and no lateral notches ..... *nigrolineata*
Pronotum with a brown central stripe divided by a narrow yellow line; wings hyaline or lightly infuscated; posterior border of female subgenital plate with a U-shaped notch and sometimes with small lateral notches 8

8 (7) Median dark area of pronotum bordered by brown areas; posterior border of female subgenital plate sinuate with a U-shaped notch; male ninth sternite without a hammer ..... *magnirufa* (in part)
Median dark area of pronotum bordered by yellow areas; posterior border of female subgenital plate with a median U-shaped notch and

sometimes with small lateral notches; male ninth sternite with a hammer ..... See text under *A. chiapasa*

9 (6) Median dark area of pronotum bordered by brown areas; posterior border of female subgenital plate sinuate with a median U-shaped notch ..... *magnirufa* (in part)
Median dark area of pronotum bordered by yellow areas; posterior border of female subgenital plate variable 10

10 (9) Head anterior to ocelli yellowish or brownish, without definite pattern; female subgenital plate variable in shape 11
Head anterior to ocelli with a large mushroom- or T-shaped mark, the stem arising from the ocellar area; posterior border of female subgenital plate distinctly 4-lobed, the smaller, inner lobes well defined ..... *sulana*

11 (10) Head rather uniformly yellow brown; posterior border of pronotum usually straight; posterior border of female subgenital plate 4-lobed, the inner lobes ill defined ..... *nigrocincta*
Ocellar area distinctly darker than rest of head; posterior border of the pronotum usually concave; female subgenital plate with a median notch, no distinct lobes 12

12 (11) Head anterior to ocelli yellow, the contrasting dark ocellar area blending rapidly to surrounding yellow area; subgenital plate of female with a broad V-shaped notch, no lateral notches; wings hyaline ..... *dampfi*
Head anterior to ocelli yellow brown, ocellar area usually somewhat darker than surrounding area; female subgenital plate with a U-shaped median notch, often with small lateral notches; wings sometimes lightly infuscated ..... *chiapasa*

13 (5) Median clear yellow area of pronotum half or more the width of the pronotum (Fig. 7) 14
Median clear yellow area of pronotum a third or less the width of the pronotum (Fig. 9) 15

14 (13) Large species, male forewing at least 14 mm., female forewing at least 19 mm.; female subgenital plate 4-lobed ..... *quadriloba*
Small species, male forewing less than 11 mm., female forewing less than 13 mm.; female subgenital plate with a median U-shaped notch ..... *flavominuta*

15 (13) Legs banded, dark brown and yellow areas squarely delimited 16
Legs uniform in color or brown and yellow areas blend gradually 17

16 (15) Head with a sharply defined quadrangular black spot above including the ocelli; female subgenital plate with a broad V-shaped notch ..... *blanda*
Head without a sharply defined quadrangular black spot but may be dark in ocellar area; female subgenital plate with a U-shaped notch and small lateral notches ..... *tristani*

17 (15) Median yellow stripe less than one quarter of the width of the pronotum 18
Median yellow stripe a quarter or more of the width of the pronotum 19

18 (17) Head strikingly patterned; tails annulate; wings tinged with brown, not infuscate; subgenital plate of female with a V-shaped notch; male ninth sternite without a hammer ..... *cincta*
Head not strikingly patterned; tails not annulate; wings infuscate; subgenital plate of female with a narrow, U-shaped notch; male ninth sternite with a hammer ..... *hoogstraali*

19 (17) Median yellow stripe a third or more of the width of the pronotum; female subgenital plate variable; male with a hammer on ninth sternite 20
Median yellow stripe about a quarter of the width of the pronotum; female subgenital plate with a U-shaped notch; male without a hammer on the ninth sternite ..... *dilaticollis*

20 (19) Segments of tail bicolored on at least the outer half; female subgenital plate with a small median notch ..... *flavolineata*
Segments of tail not bicolored; female subgenital plate 4-lobed ..... *crenulata*

REFERENCES

BURMEISTER, HERMANN 1839—*In* Handbuch der Entomologie, Berlin, 880 pp.

HAGEN, HERMANN A. 1861—Synopsis of the Neuroptera of North America, Smithsonian Institution, Washington, D.C., pp. 24-25.

KLAPÁLEK, FR. 1909—Vorläufiger Bericht über exotische Plecopteren. Wiener ent. Ztg. 28:228.

NAVAS, R. P. L. 1924—Plecópteros. *In* Insectos de la América Central. Bróteria, Ser. Zool. 21:74-75.

———1932—Plecoptera. *In* Alcuni insetti del Museo di Zoologia della R. Università di Torino. R. Università Torino (Turin), Mus. Zool e Anat. Compar. Bol. 42, ser. 3, no. 26:29-30.

NEEDHAM, JAMES G., AND ELSIE BROUGHTON 1927—Central American stoneflies, with descriptions of new species (Plecoptera). N. Y. Ent. Soc. Jour. 35:109-120.

PICTET, FRANÇOIS-JULES 1841—Histoire naturelle générale et particulière des insectes Névroptères. Fam. des Perlides, pp. 227-240.

WALKER, FRANCIS 1852—Perlides. *In* Catalogue of the specimens of neuropterous insects in the collection of the British Museum. Part I (Phryganides-Perlides), pp. 154-158.

Observations on "diamond willow," with Particular Reference to Its Occurrence in Alaska

H. J. LUTZ
Alaska Forest Research Center, U. S. Forest Service
and
School of Forestry, Yale University

The term "diamond willow" seems to have first been applied in the middle and upper Missouri River valley to willows that showed peculiar diamond-shaped depressions on their stems. When the stems were carved or otherwise finished, a striking pattern resulted from the curious diamond-shaped cavities and the contrast between the white or cream sapwood and reddish-brown heartwood. Unusual and very attractive canes were fashioned from this wood. The wood of the "diamond willow" was also regarded as very durable, and was said to be equal to red cedar in this respect. Posts, stakes and rails of "diamond willow" were used in fences by the early settlers.

History of "diamond willow" in the West

Willows with diamond-shaped depressions on their stems were probably known in the Missouri River valley around the middle of the nineteenth century, or earlier. However, the identity of the species involved remained confused for many years. Burgess (1877) was convinced that the so-called "diamond willow" and "red willow" were new species rather than *Salix cordata* with a variety. It would appear that he was rather impatient when he wrote: "How long shall we wait for names to be assigned by the Masters? Or, shall we who alone have the tree, alive, or in lumber, to study with all due care, call them *Salix rhomboidea* and *Salix rhomboi-indentata?* For *both* species are *noted* for their diamond-shaped depressions in root and trunk, from which our most unique canes are made."

The lively interest in "diamond willow" during the years following the paper by Burgess is indicated by the appearance, in 1883, of a note entitled "*Le Saule diamant*" in a Swiss forestry journal. The note, signed by W. Brière, was a French translation of an article by Robert W. Farnas [sic] and originally published in the *Weekly Bulletin* of San Francisco, January 3, 1883. The writer of the original article was well acquainted with "diamond willow" and was deeply interested in encouraging its propagation. In fact, four specimens for planting were sent to Vevey, Switzerland, which is located on Lake Geneva. Persistent efforts by the present writer to locate a copy of the January 3, 1883, issue of the San Francisco Weekly Bulletin in the United States have met with failure. It is certain, however, that the "Robert W. Farnas" quoted in the Swiss forestry journal was actually Robert W. Furnas, one-time governor of the state of Nebraska and later an agent

in the U. S. Department of Agriculture. In 1884 Furnas, writing on forest conditions in Nebraska, remarked as follows (p. 319): "Valuable characteristics are noted of a willow growing spontaneously along the Missouri River, from the mouth of the Big Nemaha south, to the Yellowstone north, familiarly known as 'diamond willow.' Professor Sargent names it *Salix cordata* var. *vestita.* Experience demonstrates it to be as durable almost for underground uses, posts, etc., as red cedar. Northern Indians seem to have known of its valuable characteristics. They call it 'twat,' which, interpreted, signifies *durable.*"

In the report (Anon., 1885) of the fifty-eighth meeting of the Biological Society of Washington, held in February 1884, it was stated that "Professor Lester F. Ward exhibited specimens of the 'diamond willow,' a form of *Salix cordata* occurring in the Upper Missouri region, distinguished by a great exaggeration of the scars left by the early growth of limbs, which form a series of large diamond-shaped cavities in the wood. He also exhibited some remarkable canes carved by people of that region from saplings of this species. Prof. Seaman advanced the theory that the scars were produced by a fungus or an insect."

Sargent (1889) believed that *Salix cordata,* and its forms, did not attain tree size. In one of his notes on North American trees is the following comment: "*Salix cordata,* var. *vestita* Andersson. The so-called Diamond Willow of Nebraska and Dakota, may be dropped from the Silva. It is not probable that any form of *Salix cordata* ever becomes a tree; and the large specimens on the banks of the Missouri River in Dakota, with peculiar diamond markings, if they exist at all, belong probably to *S. amygdaloides.*" Sargent did not drop *Salix cordata* var. *vestita* Andersson from his Silva but retained it under the name *Salix Missouriensis* (Sargent, 1896). In his Silva, Sargent included in the section dealing with *Salix cordata* var. *Mackenzieana* the following note: "A form of *Salix cordata,* the so-called Diamond Willow (*Salix cordata* var. *vestita,* in part at least of many authors but not of Andersson), frequently confounded with *Salix Missouriensis,* is remarkable for the arrest of wood growth at the atrophied branchlets, causing the presence of large diamond-shaped depressions on the stems. . ."

In 1895 the eminent American salicologist Bebb observed that "Salix Missouriensis has been mixed up with the so-called 'Diamond Willow' of the Upper Missouri, but is there any reliable evidence of any connection whatever between the two?" Bebb must have doubted that "diamond willow" attained sufficient size for fence posts, for he raised the question, "Has a stick of 'Diamond Willow,' with the 'diamonds' on it, so there could be no mistake, ever been seen large enough for a fence-post?" One year later, Sargent (1896), in his Silva, reported such use for both "so-called Diamond Willow" (*Salix cordata* var. *Mackenzieana*) and for *Salix Missouriensis.* Williams (1895) also noted the use of "diamond willow" for posts, stakes and rails in eastern Nebraska and western Iowa.

Lamb (1915) wrote that: "The diamond willow group has a wide distribution, and over a considerable portion of its range it occurs with great frequency. . . . It has numerous forms, many of which have been given a variety of names or have been classed as separate species. . . . The Missouri River type occasionally attains a height of 50 feet and a diameter of 18 inches, but as a rule none of the forms reaches large size. . . .In portions of the dry prairie region diamond willow posts have been far more durable than any other native species." Lamb designated "diamond willow" as *Salix cordata* Mühl.

Rydberg (1917), Sudworth (1927), and Kirkwood (1930) mentioned "diamond willow" under the name *Salix Mackenzieana* Barratt. Little (1953) gives "diamond willow" as one of the common names of the Missouri River willow, *Salix eriocephala* Michx. He also states that *S. eriocephala* includes variations formerly known as two distinct species, *S. cordata* Mühl. and *S. missouriensis* Bebb.

"DIAMOND WILLOW" IN ALASKA

The existence in Alaska of willows with diamond-shaped depressions on the stems must have been known by 1900 or thereabouts, if not considerably earlier. In 1925 I saw carved "diamond willow" stems in Valdez, Alaska, and was told that they came from the Copper River region in the interior. The earliest published record of "diamond willow" in Alaska seems to be that of Baxter and Wadsworth (1939). They observed the presence of cankers on the feltleaf willow, *Salix alaxensis* (Anderss.) Cov., and stated, "Young willows with these diamond-shaped cankers are often cut and used for ornamental purposes. The bark is removed from the sticks, and the wood is highly polished and finished. Commonly cankered willow is referred to as 'diamond willow'." Dr. William A. Setchell had collected willows in Alaska in 1931-1932 and brought back stem specimens with diamond-shaped markings. In 1940 Ball wrote as follows: "At Gulkana in Alaska, Dr. Setchell observed beautifully bicolored log banisters displaying diamond markings. On inquiry, he learned that they were willow poles brought by Indians from the swamps. At Gulkana Roadhouse he found that the Indians had brought in a small log, now in the University botanical museum, and the makings of a beautiful walking stick, now a highly cherished possession of the writer. The material was from *Salix alaxensis*, a tree willow not previously known to produce 'diamonds'."

During the summers of 1950, 1951, 1952 and 1957, while working in Alaska, the writer had the subject of "diamond willow" in mind and made numerous collections of stems showing diamond-shaped markings, together with botanical material from the same specimens. The following willows were found with characteristic markings: Bebb willow, *Salix bebbiana* Sarg.; smooth Bebb willow, *S. bebbiana* var. *perrostrata* (Rydb.) Schneid.; park willow, *S. pseudomonticola* Ball; littletree willow, *S. arbusculoides* Anderss.; and Scouler willow, *S. scou-*

leriana Barr. It appears that Bebb willow is the principal source of choice stems with numerous and large diamond markings. Feltleaf willow, *S. alaxensis* (Anderss.) Cov., was occasionally seen and examined but I never found it with diamond-shaped depressions. The fact that most of the "diamond willow" in the Gulkana section appears to be *S. bebbiana* or the variety *perrostrata*, adds to the interest of Setchell's stem specimens. These stems were brought in by Indians and were reported to have come from *S. alaxensis*. Certain evidence that *S. alaxensis* develops diamond-shaped depressions is supplied by Baxter and Wadsworth (1939). A mile or two below the junction of the Koyukuk and Yukon rivers they found "diamonds" (cankers) prevalent in willow stands 13 years old, and in a stand 40 to 45 years old, roughly half the willows were affected.

Although not known to occur in Alaska, *Salix discolor* Mühl. also exhibits diamond-shaped depressions. In the vicinity of Pigeon Lake,

Fig. 1.—A pure stand of Bebb willow on a high terrace in the Tazlina River valley, Alaska. Both *Salix bebbiana* Sarg. and the variety *perrostrata* (Rydb.) Schneid. are represented. Average diameter is about 3 inches and maximum diameters are 6 to 8 inches; average height is 15 to 25 feet. Many of the larger stems show diamond-shaped markings.

southwest of Edmonton, Alberta, Canada, the Indians collect stems of this willow from which they make canes to sell to tourists.

Willows with diamond markings on the stems are known to occur along most of the large rivers, and their tributaries, in the Alaska interior. The Copper River country has a local reputation as a principal source of "diamond willow" but good material is also found in the valleys of the Susitna, Matanuska, Yukon and Tanana rivers. In fact, "diamond willow" may be expected throughout all the forested country of the interior (Fig. 1).

CHARACTERISTICS OF "DIAMOND WILLOW"

The sapwood is usually thin, varying from about 0.15 to 0.4 inch thick (averaging 0.2 to 0.3 inch) and is white or cream colored. It

Fig. 2.

Fig. 3.

Fig. 2.—Bebb willow, *Salix bebbiana* Sarg., showing well-developed diamond-shaped lesions. This tree was 7.3 inches in diameter, 30.5 feet in height, and 107 years of age. Near Skilak Lake, Kenai Peninsula, Alaska.

Fig. 3.—Showing a deep diamond-shaped lesion, with characteristic dead branch in the center, on Bebb willow, *Salix bebbiana* Sarg., about 7 inches in diameter.

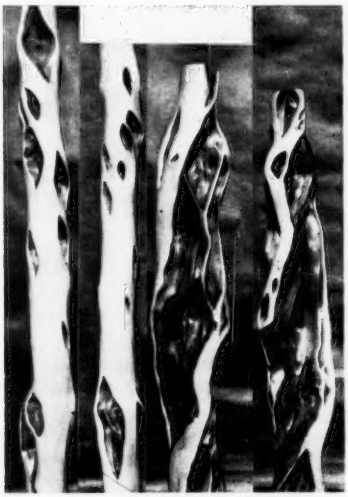


Fig. 4.—Stems of "diamond willow," *Salix bebbiana* Sarg., that have been polished. The stems on the left are 3.5 inches in diameter and 72 years old; the stems on the right are 4.6 inches and 80 years old. Collected in the Copper River valley, near the mouth of the Gakona River, Alaska.

generally shows 8 to 12 annual layers of growth. The heartwood color varies but is generally reddish brown, contrasting strongly with the sapwood. The wood in the diamond-shaped depressions is heartwood; in nature this heartwood is covered by dead bark that adheres very tightly.

In the center of each "diamond," at the bottom of the depression, one usually but not invariably finds a dead branch, or branch stub (Figs. 2 and 3). Individual "diamonds" are commonly two to three times longer than wide; the long axis is parallel with the grain of the wood. On large stems, individual "diamonds" may be five or more inches wide and three to four inches deep but on most stems they are one to three inches wide and one to two inches deep. As stems become old, two or more adjacent "diamonds" may be joined when the cambium on the intervening ridge, or ridges, dies. This leads to curious patterns and to flattening in the segment of the stem involved (Fig. 4).

The depressions or "diamonds" on willows appear to be caused by a fungus, or perhaps better, by fungi. It may be recalled that Seaman in 1884 suggested that they were caused by a fungus or an insect (Anon., 1885). In 1931 Schreiner reported that *Valsa sordida* Nitschke caused cankers on *Populus*. He stated that, "Cankers on large branches and trunks usually start around the base of dead stubs or smaller branches which have been killed by the fungus." Schreiner also noted that, ". . .the fungus frequently kills the living bark around the

canker at about the same rate as the growth of this tissue, and a rather deep hole or scar, often the shape of the original canker, results after a year or so." While working in the Fortymile River region of Alaska in 1957 the writer encountered quaking aspen, *Populus tremuloides* Michx., that exhibited large diamond-shaped depressions on the boles. These depressions were closely similar to those encountered on "diamond willow."

Baxter and Wadsworth (1939) found valsa cankers prevalent on feltleaf willow, *Salix alaxensis* (Anderss.) Cov., along the Yukon River, a mile or two below the mouth of the Koyukuk River. The fungus responsible for the cankers was *Valsa sordida*. The extent to which this fungus is involved in producing the lesions on willows other than *Salix alaxensis* is not clear. Neither is it certain that other fungi may not be involved. These are problems for the pathologist.

Willows showing the diamond-shaped depressions appear most prevalent in dense clumps or thickets where competition is intense and on poor sites where growth is slow. They may also be found in mixed stands of white spruce, *Picea glauca* (Moench) Voss, and Alaska paper birch, *Betula papyrifera* Marsh var. *humilis* (Reg.) Fernald & Raup.

Diameter and age data were secured for a number of willows showing characteristic "diamonds."

Species	Diameter inside bark, inches	Total age, years
Salix bebbiana		
" "	1.5	54
" "	1.6	49
" "	1.7	33
" "	1.8	55
" "	2.0	49
" "	2.3	58
" "	2.5	38
" "	2.5	51
" "	2.7	74
" "	3.0	65
" "	3.0	62
" "	3.2	70
" "	3.3	32
" "	3.4	54
" "	3.5	72
" "	3.7	70
" "	4.6	80
" "	6.4	107
" "	6.6	146
Salix bebbiana var. perrostrata	1.3	55
" " " "	1.9	45
" " " "	2.7	80
" " " "	2.7	64
Salix pseudomonticola	1.2	41
Salix arbusculoides	2.0	40

Bebb willow in Alaska may attain a maximum diameter of about 8 to 10 inches and a height of around 25 feet. Maximum age attained appears to be about 150 years. Coville (1901) reported Bebb willow attaining a diameter of 8 inches and a height of 10 to 25 feet at Kasilof on the Kenai Peninsula. Preble (1908) stated that Bebb willow in the upper Mackenzie River reaches nearly a foot in diameter and 25 feet in height.

The wood of "diamond willow" has a reputation for durability. This was first noted by early settlers in the Missouri River valley and reported by early writers such as Burgess (1877), Furnas (1884), Williams (1895) and Sargent (1896). One is also impressed with the durability of dead, standing Bebb willow in Alaska. Fire-killed willow is known to have remained sound for as long as 75 years. Keele (1905) reported on forest conditions in the country between the Peel and McQuesten Rivers in Yukon Territory, Canada. He wrote: "In the spruce forests of the valleys, dry willow trees are found entangled in the living spruce in great quantity. These willows are often three or four inches in diameter and 10 to 20 feet high. They evidently protected the spruce seedlings but were finally overshadowed by them. This supply of dry wood is of great benefit to the voyageurs as it ensures a good camp fire in wet weather and during winter travel."

Large live willows, on the other hand, are often attacked by fungi causing decay of the heartwood. Baxter and Wadsworth (1939) mention as most common *Favolus canadensis* Klotzsch., *Pholiota adiposa* Fr., and *Trametes suaveolens* Fr. Frequently large stems that appear very promising turn out to be so heart rotted as to be useless.

USES OF "DIAMOND WILLOW" IN ALASKA

The principal uses of "diamond willow" in the North involve stem sections in the round. More is probably used for making decorative canes than for any other single purpose. The wood is also used in fashioning floor lamps and table lamps. When carefully finished these lamps are most attractive and bring good prices from tourists and local collectors. It would seem that this use may well increase. Stem sections for display purposes may be purchased at some of the roadhouses but the supply of well-carved and well-finished specimens is limited. Rustic furniture is built with willow and is in use at some of the roadhouses and in private homes. In one roadhouse is a staircase, the newel posts and balusters of which are made of "diamond willow." Finishing "diamond willow" and fabricating it into useful articles is a home handicraft that some people find rewarding in a creative as well as a commercial sense.

SUMMARY

Around the middle of the nineteenth century, or perhaps earlier, willows in the middle and upper Missouri River valley were observed

with striking diamond-shaped depressions on their stems. The term "diamond willow" was used as a common name for these trees. For years the identity of the species involved was confused and many different scientific names were applied. The western species now most commonly referred to as "diamond willow" is the Missouri River willow, *Salix eriocephala* Michx. which includes variations formerly known as two distinct species, *S. cordata* Mühl. and *S. missouriensis* Bebb.

Since 1900, or earlier, it has been known that there were also willows in Alaska having diamond-shaped depressions on the stems; "diamond willow" was the name by which they were known locally. In recent years it has become evident that there is not *one* "diamond willow" species in Alaska; rather, there are at least five, and probably more, species of willow involved. Included are the following: *Salix bebbiana* Sarg., *S. bebbiana* var. *perrostrata* (Rydb.) Schneid., *S. pseudomonticola* Ball, *S. arbusculoides* Anderss., *S. scouleriana* Barr., and *S. alaxensis* (Anderss.) Cov. The occurrence of "diamond willow" in Alaska is not restricted to any one section. Characteristic stems are to be found from the Kenai Peninsula northward throughout the timbered country of the interior.

It appears that the diamond-shaped markings are caused by a fungus, or perhaps better, by fungi. *Valsa sordida* Nitschke is held to be responsible for the lesions on feltleaf willow and may also attack other willows. A full understanding of the causal organisms must await further study.

REFERENCES

ANON. 1885—Fifty-eighth meeting, February 23, 1884. Proceedings of the Biological Society of Washington 2:LI-LIII.

BALL, CARLETON R. 1940—Dr. Setchell and Alaska willows. Madroña *5*(7):231-232.

BAXTER, DOW V. AND FRANK H. WADSWORTH 1939—Forest and fungus succession in the Lower Yukon Valley. University of Michigan, School of Forestry and Conservation. Bul. 9. 52 pp.

BEBB, M. S. 1895—Notes on some arborescent willows of North America. —II. Garden and Forest *8*:372-373.

BRIÈRE, W. 1883—Le Saule diamant. Schweizerische Zeitschrift für das Forstwesen. Jahrgang 1883. Pp. 104-106.

BURGESS, ROBERT 1877—Some Iowa plants. Botanical Gazette *2*:73-75.

COVILLE, FREDERICK V. 1901—The willows of Alaska. Papers from the Harriman Alaska Expedition. XXIV. Proceedings of the Washington Academy of Sciences *3*:297-362.

FURNAS, R. W. 1884—Report on the forest condition and lumber and wood trade of western states and territories. *In*: Report on forestry, prepared by Nathaniel H. Egleston. Vol. 4. Pp. 255-337. U. S. Department of Agriculture.

KEELE, J. 1905—Forests of the Yukon Territory. Canadian Forestry Journal *1*:65-69.

KIRKWOOD, J. E. 1930—Northern Rocky Mountain trees and shrubs. xvii + 340 pp. Stanford University Press, California.

LAMB, GEORGE N. 1915—Willows: their growth, use, and importance. U. S. Dept. of Agr. Bul. 316. 52 pp.

LITTLE, ELBERT L. JR. 1953—Check list of native and naturalized trees of the United States (including Alaska). Forest Service, U. S. Dept. Agr. Agriculture Handbook No. 41. 472 pp.

PREBLE, EDWARD A. 1908—A biological investigation of the Athabaska-Mackenzie Region. U.S. Dept. Agr., Bureau of Biological Survey. North American Fauna. No. 27. 574 pp.

RYDBERG, P. A. 1917—Flora of the Rocky Mountains and adjacent plains. xii + 1110 pp. Published by the author, New York.

SARGENT, C. S. 1889—Notes upon some North American trees. —XIII. Garden and Forest *2*:484.

SARGENT, CHARLES SPRAGUE 1896—The silva of North America. A description of the trees which grow naturally in North America exclusive of Mexico. Vol. 9. vii + 190 pp. Houghton, Mifflin and Co., Boston.

SCHREINER, ERNST J. 1931—Two species of *Valsa* causing disease in *Populus*. American Journal of Botany *18*:1-29.

SUDWORTH, GEORGE B. 1927—Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr., Misc. Cir. 92. 295 pp.

WILLIAMS, THOMAS A. 1895—Notes on the flora of a prairie state. I. The diamond willow in South Dakota. Garden and Forest *8*:493-494.

Studies of the Byron Bog in Southwestern Ontario VIII. Seasonal Distribution of Filth Flies[1]

W. W. JUDD
University of Western Ontario, London, Ontario

In the description of the Byron Bog (Judd, 1957) it was pointed out that one method of collecting insects was the use of a baited trap set out in an open area in the *Chamaedaphnetum calyculatae* association. The position of the trap in the bog is shown on a map of the bog (Judd, 1957) and its structure and use are described (Judd, 1956). The trap was in operation during 1956 from May 15 to November 15. Each day the insects accumulated in the trap were removed from the trap, sorted, and counted according to species and sex. Among the insects so collected were nineteen species of filth flies in the families Anthomyiidae, Muscidae, Calliphoridae and Sarcophagidae. They were all species represented in the collections of flies made during the survey of flies conducted at London during 1953 (Judd, 1956) and they were identified by methods described in the account of that survey and by comparison with specimens collected in the survey. The numbers of flies of the nineteen species collected are shown in Table I. The Byron Bog is about three miles west of London where the survey of 1953 was conducted; and comparisons between the numbers of flies of each species may be made by consulting Table I of the present paper and Table "I" of the report of the survey of 1953 (Judd, 1956).

Acknowledgment.—The collections were made and the data assembled while the writer held a Summer Research Associateship of the National Research Council of Canada during the summers of 1956 and 1957.

Account of Total Catch

During the period May 15 to November 15, 20,848 flies were trapped. The catch of flies during May was light with the population building up during June and reaching a peak in summer on July 27 (478 flies) (Fig. 1). This was close to the date, July 24, on which the maximum number of flies was caught in the survey at London (Judd, 1956). The population fell off during August and September and then built up to another peak in the fall with the greatest number of flies, 713, occurring on November 6. This fall population was made up largely of *Pollenia rudis* (Fig. 18). In the survey of 1953 two of the flies which contributed largely to the peak of abundance in July were *Phaenicia sericata* and *Pollenia rudis*. Of these two species *P.*

[1] Contribution from the Department of Zoology, University of Western Ontario; a project supported by funds from the government of Ontario granted through the Ontario Research Foundation.

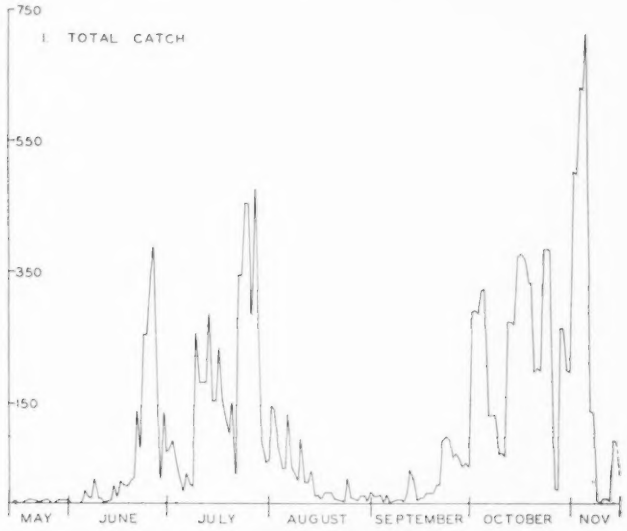


Fig. 1.—Numbers of all Anthomyiidae, Muscidae, Calliphoridae and Sarcophagidae trapped during 1956.

rudis accounted for almost half the catch of flies in 1956 while *P. sericata* was present in much smaller numbers. Thus *Pollenia rudis* was the species which contributed the greatest number of flies to the peak of abundance in the fall in the Byron Bog.

Account of Species Collected

MUSCINA STABULANS (Fallén)

June 20 to November 15: 1,343 flies (peaks of abundance — July 24: 22 flies; October 22: 43 flies) (Fig. 2).

This species occurred throughout the season. Its peak of abundance in mid-July coincides with that found for this species at London (Judd, 1956) and in Michigan (Williams, 1956).

FANNIA CANICULARIS (L.)

June 17 to November 6: 182 flies (peaks of abundance — July 22: 12 flies; October 23: 5 flies) (Fig. 3).

This species showed two peaks of abundance, as it did in London (Judd, 1956). The first was in July, as it was in Michigan (Schoof *et al.*, 1956).

TABLE I.—Number of flies collected in trap during 1956

Taxon	Male	Female	Total
ANTHOMYIIDAE			
Muscina stabulans	455	888	1,343
Fannia canicularis	121	61	182
Pyrellia serena	102	86	188
MUSCIDAE			
Musca domestica	62	64	126
Stomoxys calcitrans	2	1	3
Orthellia caesarion	132	156	288
CALLIPHORIDAE			
Protophormia terrae-novae	10	16	26
Phormia regina	2,206	3,312	5,518
Bufolucilia silvarum	78	78	156
Lucilia illustris	47	186	233
Phaenicia caeruleiviridis	368	567	935
Phaenicia sericata	97	257	354
Calliphora livida	105	110	215
Calliphora terrae-novae	18	16	34
Calliphora vicina	50	37	87
Calliphora vomitoria	24	207	231
Cynomyopsis cadaverina	346	346	692
Pollenia rudis	5,432	4,800	10,232
SARCOPHAGIDAE			
Wohlfahrtia vigil	4	1	5
TOTAL			20,848

PYRELLIA SERENA (Meigen)

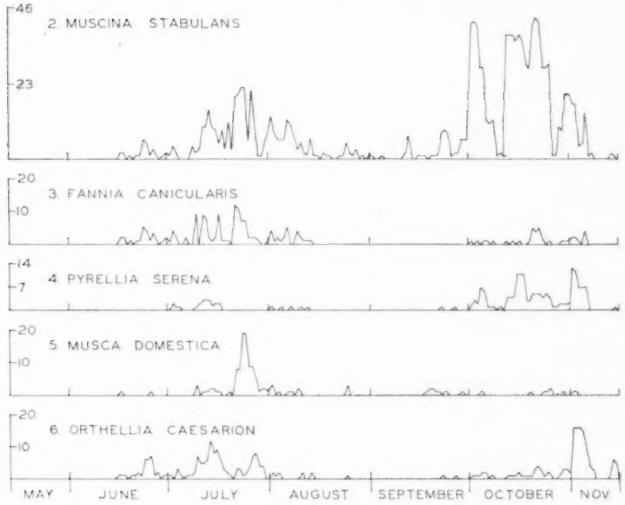
July 3 to November 15: 188 flies (peak of abundance — November 2: 13 flies) (Fig. 4).

The greatest numbers of this species occurred late in the fall, as was the case at London (Judd, 1956). This is in accord with the findings of Holmquist (1928) who reports that it hibernates as an adult. Holmquist found it common in a flood plain. The Byron Bog has permanent water in its central region and its outer regions are damp or flooded most of the year (Judd, 1957).

MUSCA DOMESTICA L.

June 17 to November 3: 126 flies (peak of abundance — July 25: 19 flies) (Fig. 5).

This species was one of the less common flies trapped. Its peak of abundance in July is in accord with the results of surveys in London (Judd, 1956), Kansas (Savage and Schoof, 1955) and Arizona (Siverly and Schoof, 1955). There was, however, no heavy population in the fall as there was at London in 1953.



Figs. 2-6.—Numbers of five species of flies trapped daily in 1956.

STOMOXYS CALCITRANS (L.)

Only three of these flies were trapped, two males (November 4, 5) and one female (October 1). The presence of this fly in the fall is in accord with the results of the survey at London.

ORTHELLIA CAESARION (Meigen)

June 16 to November 15: 288 flies (peaks of abundance — July 14: 12 flies; November 3: 16 flies) (Fig. 6).

This species showed a peak of abundance in the fall, as was the case at London, but was also prevalent during the summer, which was not the case at London.

PROTOPHORMIA TERRAE-NOVAE (Robineau-Desvoidy)

June 17 to October 26: 26 flies (peak of abundance — June 25: 3 flies) (Fig. 8).

This species was one of the scarcer flies in the population, as it was at London (Judd, 1956) and in Michigan (Williams, 1956).

PHORMIA REGINA (Meigen)

May 20 to November 6: 5,518 flies (peak of abundance — June 27: 341 flies) (Fig. 7).

This was the second most abundant fly in the population. Its peak

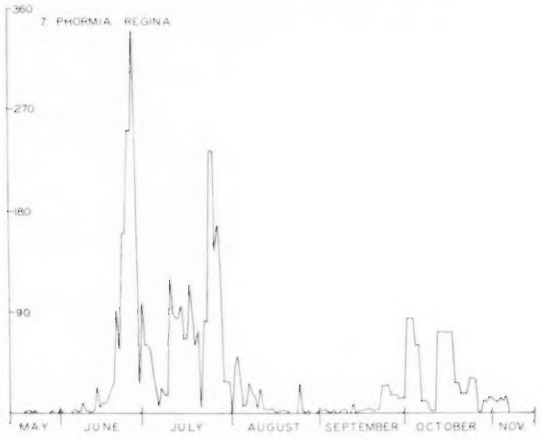


Fig. 7.—Numbers of *Phormia regina* trapped daily during 1956.

of abundance in June is in accord with the results of the survey in Kansas (Savage and Schoof, 1955), although other authors record it as most abundant later in the year (e.g. Judd, 1956).

BUFOLUCILIA SILVARUM (Meigen)

June 17 to November 1: 156 flies (peak of abundance — July 10: 14 flies) (Fig. 9).

The peak of abundance in July is in accord with that found for this species at London (Judd, 1956), in Michigan (Williams, 1956) and in New York (Schoof *et al.*, 1956). It is a parasite of frogs and toads (Hall, 1947). Several kinds of frogs, i.e., leopard frog, pickerel frog, green frog, swamp tree-frog, green tree-frog and spring peeper, were common in the Byron Bog.

LUCILIA ILLUSTRIS (Meigen)

June 9 to November 2: 233 flies (peaks of abundance — July 14: 12 flies; October 17: 16 flies) (Fig. 10).

The peaks of abundance of this species in July and October are in accord with those at London in 1953 (Judd, 1956). It was found to be most abundant in July in Michigan (Schoof *et al.*, 1956; Williams, 1956).

PHAENICIA CAERULEIVIRIDIS (Macquart)

June 15 to November 7: 935 flies (peaks of abundance — July 14: 66 flies; October 17: 38 flies) (Fig. 11).

This species was relatively more abundant in the Byron Bog than at London. This is in accord with the estimate of Hall (1947) who

records that it is a common species in woods and fields, but not abundant about houses.

PHAENICIA SERICATA (Meigen)

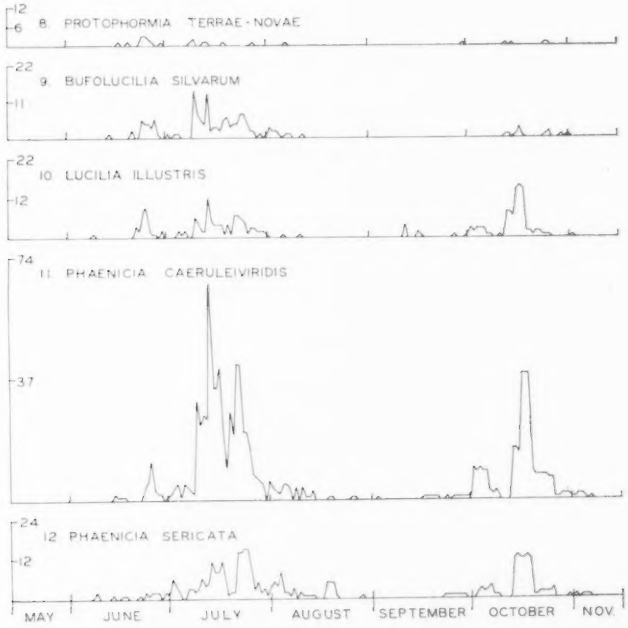
June 9 to November 6: 354 flies (peaks of abundance — July 24: 15 flies; October 17: 13 flies) (Fig. 12).

The major peak of abundance of this species was on July 24, as it was at London. It was relatively far less abundant than at London, doubtless owing to the fact that it occurs most abundantly around garbage in cities (Hall, 1947; Siverly and Schoof, 1955).

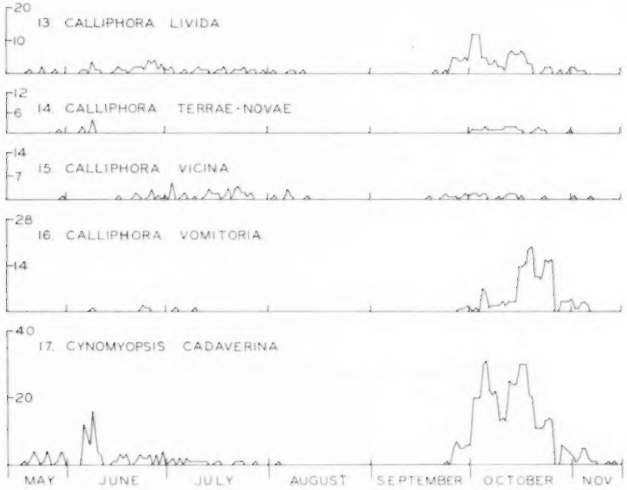
CALLIPHORA LIVIDA Hall

May 21 to November 5: 215 flies (peak of abundance — October 4: 12 flies) (Fig. 13).

This species was present through most of the season with its peak of abundance in October. Its presence in the country is in accord with the estimate of Judd (1956) who found it most abundant at the outskirts of London.



Figs. 8-12.—Numbers of five species of flies trapped daily during 1956.



Figs. 13-17.—Numbers of five species of flies trapped daily during 1956.

CALLIPHORA TERRAE-NOVAE Macquart

May 30 to November 1: 34 flies (peak of abundance — June 9: 4 flies) (Fig. 14).

This fly was one of the scarcer species, as it was at London and its occurrence in spring and fall is also in accord with its distribution at London.

CALLIPHORA VICINA Robineau-Desvoidy

May 31 to November 7: 87 flies (peak of abundance — July 3: 5 flies) (Fig. 15).

This was one of the scarcer flies, but it occurred through most of the season.

CALLIPHORA VOMITORIA (L.)

June 9 to November 6: 231 flies (peak of abundance — October 21: 20 flies) (Fig. 16).

This species was relatively more abundant in the bog than at London and its peak of abundance in the bog and at London occurred on the same day, October 21.

CYNOMYOPSIS CADAVERINA (Robineau-Desvoidy)

May 19 to November 14: 692 flies (peak of abundance — October 6: 31 flies) (Fig. 17).

This species was commonest in spring and fall, as it was at London.

POLLENIA RUDIS (Fabr.)

May 16 to November 15: 10,232 flies (peaks of abundance — July 27: 252 flies; November 6: 660 flies) (Fig. 18).

This species was the most abundant of the flies, accounting for almost half the total catch. One peak of abundance was at the end of July, as it was at London, but its greatest abundance occurred in November, which is in accord with the fact that this fly hibernates as an adult. It is parasitic, in its larval stage, in earthworms and its great abundance around the Byron Bog is probably due to the predominance of damp, rich earth which doubtless supports a large population of earthworms.

WOHLFAHRTIA VIGIL (Walker)

Five of these flies were trapped, one male on each of June 19, 20, 22 and 24 and one female on June 14. This fly was relatively more abundant in the bog than at London and was trapped in June rather than in July, the month when it was caught in London.

FLIES TRANSPORTING POLLINIA OF MILKWEED

During the counting of the flies collected in the survey conducted at London in 1953, several flies were found to be transporting pollinia of milkweed, *Asclepias syriaca* (Judd, 1955). When the flies from the Byron Bog were counted they also were examined for the presence of pollinia. A corpusculum bearing two pollinia was found clamped over the labellum of the proboscis on two flies; all other pollinia were

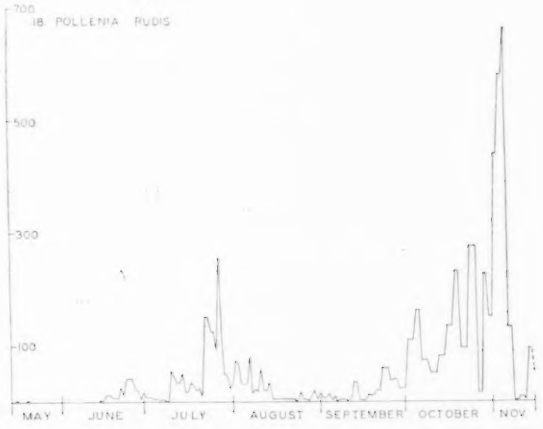


Fig. 18.—Numbers of *Pollenia rudis* trapped daily during 1956.

in pairs on corpuscula clamped over the pulvilli on the flies' feet. The distribution of corpuscula (bearing two pollinia each) on ten flies was as follows:

Phormia regina (Meigen)—July 20: 1 each on left prothoracic leg and left mesothoracic leg; July 28: 1 on right prothoracic leg.

Protophormia terrae-novae (Robineau-Desvoidy)—July 13: 1 on each of left prothoracic leg and right metathoracic leg.

Pollenia rudis (Fabr.)—July 14: 1 on labellum and 1 each on left prothoracic leg, left mesothoracic leg and right metathoracic leg; July 25: 1 on right prothoracic leg of one fly and 1 on left mesothoracic leg of another fly; July 26: 1 on right prothoracic leg; July 27: 1 on right mesothoracic leg; July 29: 1 on right mesothoracic leg; August 3: 1 on labellum.

There were thus 16 corpuscula, bearing 32 pollinia, on the ten flies. In the survey at London in 1953 all the flies bearing pollinia were caught in July. In the Byron Bog all the flies with pollinia were caught in July except one caught on August 3. The commonest point of attachment of the pollinia on the flies caught in both surveys was on the feet of the flies. A few pollinia were attached to the labellum. In both surveys both *Phormia regina* and *Protophormia terrae-novae* were found bearing pollinia, while *Pollenia rudis* was found with pollinia only in the Byron Bog.

SUMMARY

During the period May 15 to November 15, 1956, 20,848 flies were trapped in a trap baited with malt extract set out in the *Chamaedaphnetum calyculatae* association in the Byron Bog. The flies were removed from the trap each day and sorted according to species and sex. Nineteen species in the families Anthomyiidae, Muscidae, Calliphoridae and Sarcophagidae were counted and their times of occurrence through the season were recorded. The species counted were *Muscina stabulans, Fannia canicularis, Pyrellia serena, Musca domestica, Stomoxys calcitrans, Orthellia caesarion, Phormia regina, Protophormia terrae-novae, Bufolucilia silvarum, Lucilia illustris, Phaenicia caeruleiviridis, P. sericata, Calliphora livida, C. terrae-novae, C. vicina, C. vomitoria, Cynomyopsis cadaverina, Pollenia rudis,* and *Wohlfahrtia vigil.* Pollinia of milkweed were found attached to *Phormia regina, Protophormia terrae-novae* and *Pollenia rudis.*

REFERENCES

HALL, D. G. 1947—The blowflies of North America. Thomas Say Foundation, vol. 4.

HOLMQUIST, A. M. 1928—Notes on the biology of the muscid fly, *Pyrellia serena* Meigen, with special reference to its hibernation. Ann. Entomol. Soc. Amer. 21:660-667.

JUDD, W. W. 1955—Mites (Anoetidae), fungi (*Empusa* spp.) and pollinia of milkweed (*Asclepias syriaca*) transported by calyptrate flies. Can. Entomol. 87:366-369.

———1956—Results of a survey of calyptrate flies of medical importance conducted at London, Ontario during 1953. Amer. Midl. Nat. 56:388-405.

———1957—Studies of the Byron Bog in southwestern Ontario. I. Description of the bog. Can. Entomol. 89:235-238.

SAVAGE, E. P., AND H. F. SCHOOF 1955—The species composition of fly populations at several types of problem sites in urban areas. Ann. Entomol. Soc. Amer. 48:251-257.

SCHOOF, H. F., E. P. SAVAGE AND H. R. DODGE 1956—Comparative studies of urban fly populations in Arizona, Kansas, Michigan, New York and West Virginia. II. Seasonal abundance of minor species. Ann. Entomol. Soc. Amer. 49:59-66.

SIVERLY, R. E. AND H. F. SCHOOF 1955—Utilization of various production media by muscoid flies in a metropolitan area. I. Adaptability of different flies for infestation of prevalent media. Ann. Entomol. Soc. Amer. 48:258-262.

WILLIAMS, R. W. 1956—Studies on the filth flies at the University of Michigan Biological Station, Douglas Lake, Michigan—summer 1954. Amer. Midl. Nat. 55:126-130.

Notes on Some Snakes from Mississippi

J. WILLIAM CLIBURN
Mississippi Southern College, Hattiesburg

Most of the snakes discussed in this paper were collected in Forrest County,[1] Mississippi, during 1951 and 1952, principally in the southern part of the county in the vicinity of Brooklyn, about 20 miles south of Hattiesburg. Other specimens came from the counties of Lamar, Bolivar, Pearl River, Lauderdale, Harrison, Jackson, George, Copiah, Perry, Lawrence, Warren, and Lincoln. Additional specimens were examined from Hancock, Adams, Jones, Sunflower, and Smith counties. All specimens are in the Department of Zoology Museum, Mississippi Southern College, except *Natrix t. taxispilota*, which is in the collection of the State Game and Fish Commission Museum, Jackson, Mississippi.

Forty-two distinct species and subspecies are recognized among the specimens. While not all of the forms accredited to Mississippi by Wright and Wright (1952) have been observed, it is possible to verify four species included in their problematic list, as follows: *Abastor erythrogrammus, Heterodon simus, Natrix t. taxispilota,* and *Pituophis melanoleucus lodingi.* In addition, two species not listed as occurring in Mississippi are included; these are *Natrix grahami* and *Natrix septemvittata.* More extensive collecting over the state at large would doubtless remove others from the problematic list.

Departures from nomenclature as listed by Schmidt (1953) are explained as follows: *Elaphe obsoleta confinis* is preferred by me in agreement with Neill (1954). As I use the name *E. o. confinis,* it is synonymous with *E. o. spiloides* Duméril, Bibron, and Duméril. The trinomial *Natrix t. taxispilota* and the new combination *Natrix t. rhombifera* are used following Cliburn (1956). The generic name *Agkistrodon* is used in preference to *Ancistrodon* as discussed by Klauber (1956).

Farancia abacura reinwardti Schlegel.—Four specimens: 5 mi. NW. Brooklyn (1); 5 mi. NNW. Brooklyn (3). The three males have the following variations: Subcaudals 47-50 (48); ventrals 174-179 (176); ratio of subcaudals/ventrals .263-.284 (.272). The female has 37 subcaudals, 189 ventrals, with a subcaudal/ventral ratio of .196. In other scale counts, none of these snakes vary from the type. Lengths vary from 37-126 (80) cm. One specimen was seen to feed on *Siren.* Other examples whose data are not included above are from Wesson, Lincoln Co., and Stronghope, Copiah Co.

Abastor erythrogrammus Latreille.—This fossorial snake is not so frequently encountered as is *Farancia abacura reinwardti.* One example has been observed from N. Hattiesburg. Scale data for this snake are not available.

Diadophis punctatus stictogenys Cope.—Four very small specimens are

[1] Unless othewise indicated, the specimens are from Forrest Co.

present, all having been taken in the vicinity of Brooklyn. Scale counts are not available.

Carphophis amoenus helenae Kennicott.—One small specimen was taken from under a log at a small creek 1.5 mi. N. Hattiesburg.

Heterodon platyrhinos platyrhinos Latreille.—Eight specimens: 2 mi. NE. Brooklyn (1); Brooklyn (3); 5 mi. NW. Brooklyn (1); Rock Hill, 6 mi. W. Brooklyn (1); 10 mi. S. Brooklyn (1); 13 mi. SE. Lumberton, in Pearl River Co. (1). Two males show the following differences: subcaudals 53-59; ventrals 126-130; ratio of subcaudals/ventrals .421-.454. Three females vary as follows: subcaudals 43-49 (45); ventrals 136-144 (140); ratio of subcaudals/ventrals .316-.340 (.331). Four specimens have 25 scale rows; one male has 23. All have 8-8 supralabials. Infralabials vary from 9-9 to 11-11. Postoculars vary from 2-2 to 4-4, with 3-3 as the usual number. There are wide variations among suboculars, the range being from 4-3 to 4-5. Posterior temporals range from 3-4 to 6-5, with 6-5 being the most frequent combination. Anterior temporals vary from 3-4 to 4-4. Lengths are from 19-65 (46) cm. One female is black in dorsal coloration. Additional specimens are in the collection from Wesson and Hazlehurst, Copiah Co., and from near Wesson, in Lincoln Co.

Heterodon simus Linnaeus.—One small specimen of this snake is present in the collection from 4 mi. SW. Brooklyn.

Opheodrys aestivus Linnaeus.—Thirteen specimens: Brooklyn (8); 5 mi. NW. Brooklyn (2); McLaurin (1); 8 mi. S. Hattiesburg (1); 8 mi. N. Baxterville, Lamar Co. (1). All of these have 17 scale rows, 7-7 supralabials (with the exception of one specimen, which has 6-6 supralabials); usually there are 8-8 infralabials, although two have 7-7, one has 7-8, and another has 8-7. Ventral counts vary from 149-165 (160). Number of subcaudals varies from 126-153 (139). Lengths vary from 42-94 (66) cm.

Coluber constrictor priapus Dunn & Wood.—Snakes from this region previously designated as *C. c. constrictor* are found to be *C. c. priapus*. Specimens are present from many locations in Forrest, Lamar, and Pearl River cos. *Coluber c. priapus* is more frequently encountered in copulation than is any other local form. Juveniles are rarely seen. Examination of three males reveals the following: subcaudals 77-103 (91); ventrals 167-177 (173); ratio of subcaudals/ventrals .461-.582 (.528); lengths 102, 102, and 103 cm; tail lengths 24, 26, and 29 cm; ratio of tail length/total length .235-.281 (.257). A single female has: subcaudals 97; ventrals 175; ratio of subcaudals/ventrals .554; length 102 cm; tail length 28 cm; ratio of tail length/total length .274. No variations worth noting are observed in other scale counts.

Masticophis flagellum flagellum Shaw.—Five specimens: near Chaney Creek, E. Brooklyn (1); 1 mi. N. Brooklyn (1); 5 mi. NW. Brooklyn (1); SW. George Co. (1); 10 mi. E. Columbia, Marion Co. (1). An additional specimen is present in the collection from Monticello, Lawrence Co. The three Forrest Co. specimens have 103-118 subcaudals (112); 202-206 ventrals

(205); subcaudals/ventrals ratio .500-.573 (.547). Scale rows are usually 17-15-13; one female has 19 anterior rows. The number of supralabials is 8-8; usually there are 11-11 infralabials. Lengths vary from 66-165 cm (129).

Elaphe guttata guttata Linnaeus.—Five specimens: Brooklyn (2); U.S. Highway 49, 7 mi. S. Hattiesburg (1); 5 mi. NNW. Brooklyn (1); 5 mi. SW. Wiggins, near Red Creek, Stone Co. (1); another was observed 12 mi. W. Purvis, Lamar Co. The four Forrest Co. specimens have the following: subcaudals 67-71 (69); ventrals 217-225 (222); subcaudals/ventrals ratio .298-.327 (.310). All specimens have 27 scale rows at midbody. Two have 8-8 supralabials; two have 7-7. Usually there are 10-10 infralabials. Lengths vary from 52-119 (81) cm.

Elaphe obsoleta confinis Baird and Girard.—Seven specimens: Brooklyn (2); 5 mi. NNW. Brooklyn (1); 5 mi. NW. Brooklyn (1); 8 mi. N. Baxterville, Lamar Co. (1); Magnolia State Park, Ocean Springs, Jackson Co. (1); Ramsey Springs, SE. Stone Co. (1). An additional specimen is from Wesson, Lincoln Co. Subcaudals in two males from SE. Mississippi are 94-101; ventrals 241-243; subcaudals/ventrals ratio .390-415; scale rows 27 at midbody. In four females from SE. Mississippi subcaudals range from 84-92 (89); ventrals vary from 237-252 (246); subcaudals/ventrals ratio varies from .333-.384 (.363); scale rows at midbody 25-29, two having 25. Lengths vary from 35-158 (115) cm. Body blotches vary from 28-37; tail spots very from 11-16.

Pituophis melanoleucus lodingi Blanchard.—One female is present in the collection from 7 mi. S. Hattiesburg. Total length is 145 cm, and the tail length is 19 cm. Other data are not available. The example is apparently typical of the subspecies.

Lampropeltis calligaster rhombomaculata Holbrook. — A specimen was taken while resting in bright sunlight on a gravel road 8 mi. N. Baxterville, Lamar Co. It is previously unreported for this county. This female has the following: subcaudals 42; ventrals 195; subcaudals/ventrals ratio .215; scale rows at midbody 21; supralabials 7-8; infralabials 9-9; anterior temporals 2-2; posterior temporals 3-2; length 81 cm.

Lampropeltis doliata doliata Linnaeus.—Three specimens: Broome (1); near Vestry (1) both localities SW. George Co.; 10 mi. SE. Lumberton, Pearl River Co. (1).

Lampropeltis getulus holbrooki Stejneger.—Eleven specimens: 2 mi. S. Hattiesburg (1); vicinity of Brooklyn (7); Ruth, SE. Lincoln Co. (1); New Sight (1), Wesson (1), both localities in N. Lincoln Co. In three males from SE. Mississippi, subcaudals vary from 43-52, averaging 49; ventrals vary from 209-217, averaging 213; ratio of subcaudals/ventrals .202-.244, averaging .229. In one female from SE. Mississippi, counts are as follows: subcaudals 33; ventrals 223; subcaudals/ventrals ratio .148. Infralabials vary in all four from 8-8 to 9-10. Lengths vary from 55-132 (90) cm.

Cemophora coccinea Blumenbach.—Three specimens: 8 mi. S. Meridian, Lauderdale Co. (1); Mississippi City, Harrison Co. (1); Brooklyn (1). It

is interesting to note that one of these snakes was taken in the living room of a dwelling house, and another from a drugstore. Scutellation in two specimens is as follows: subcaudals 43-46; ventrals 166-165; subcaudals/ventrals ratio .259-.279; scale rows at midbody 19; supralabials 6-6 and 5-6; infralabials 6-6; postoculars 2-2 and 1-1; length 35-29 cm.

Natrix grahami Baird and Girard.—Apparently this snake is found principally in the Yazoo-Mississippi Delta region. Two specimens have been observed from Chickasaw and Lauderdale cos., according to museum records. If these records are correct, the occurrence of this serpent in these localities leaves a question for further study. The specimen from Chickasaw Co. displays an interesting variation in that the first scale row on each side is not keeled or else very weakly so.

Natrix rigida Say.—This snake in Mississippi has been found only in the lower coastal plain east of Pearl River. It is known from several locations in south Forrest Co., and from Pearl River, Stone, and Jones cos. It is doubtful if *rigida* occurs at any great distance from the coast. One specimen is curious in that the first three scale rows are not keeled, and the fourth is only very weakly so. In this respect, at least, *rigida* seems closer to *grahami* than to *septemvittata*.

Natrix septemvittata Say.—*Natrix septemvittata* has been observed in this state only from Lauderdale County. In this specimen, the ventral stripes are vestigial and restricted to the neck region. This specimen does not seem to represent typical *septemvittata*.

Natrix taxispilota taxispilota Holbrook.—This snake is known only from Adams County in Mississippi.

Natrix taxispilota rhombifera Hallowell.—This water snake is distributed statewide in Mississippi, with the possible exception of the immediate coastal area, where it may be replaced by *N. t. taxispilota*. As discussed in a previous paper (Cliburn, 1956), this form intergrades with *taxispilota*, and is to be considered a subspecies of *taxispilota*.

Natrix cyclopion cyclopion Duméril, Bibron and Duméril.—Three specimens were examined from Ocean Springs, Jackson Co.

Natrix sipedon pleuralis Cope.—*Natrix s. pleuralis* is widely distributed in Mississippi except for the Mississippi Valley and the costal region. It has been taken extensively in Forrest Co., Copiah Co., and in Stone Co. to within 30 miles of the coast, which represents a southward extension of its range in Mississippi.

Natrix sipedon fasciata Linnaeus.—Specimens of this snake have been taken frequently in Jackson, Harrison, Stone, and Hancock cos. Examples from the western part of the range show the decided influence of *N. s. confluens*.

Natrix sipedon confluens Blanchard.—This snake is limited in range in Mississippi principally to the Yazoo, Mississippi, and Pearl River drainages.

An apparently typical specimen collected in Forrest Co. represents an eastward extension of the range of this form.

Natrix sipedon clarki Baird and Girard.—Two specimens were examined from the Gulf Coast Research Laboratory, Ocean Springs, Jackson County.

Natrix erythrogaster flavigaster Conant.—Specimens of this very common snake indicate that it is statewide in distribution.

Storeria dekayi wrightorum Trapido.—Two specimens: 5 mi. NNW. Brooklyn (1), and 5 mi. NW Brooklyn (1). Data are as follows: subcaudals 44-51; ventrals 132-134; subcaudals/ventrals ratio .333-.380; scale rows at midbody 17; supralabials 7-7; infralabials 7-7; postoculars 2-2; preoculars 1-1; anterior temporals 1-1; posterior temporals 2-2; length 300-335 mm.

Storeria occipitomaculata Storer.—Two specimens: Brooklyn (1); 5 mi. NNW. Brooklyn (1). Scale counts are as follows: subcaudals 56 in both; ventrals 114-117; subcaudals/ventrals ratio .491-.478; scale rows 15 in both; supralabials 7-6 and 6-7; infralabials 7-6 and 7-7; postoculars 2-2 and 2-3; preoculars 2-2 in both; posterior temporals 2-3 and 3-2; length 195 and 85 mm.

Haldea striatula Linnaeus.—Five specimens: Wesson, Copiah Co. (2); near Stronghope, Lawrence Co. (3).

Haldea valeriae elegans Kennicott.—Four specimens: Under stones and pine straw near Hattiesburg (2); under a log, 5 mi. W. Hattiesburg, in Lamar Co. (1); Logtown, Hancock Co. (1).

Thamnophis sirtalis sirtalis Linnaeus.—Specimens identified as this form are from the following Mississippi counties: Wayne (1); Forrest (2); Hancock (6); Lamar (4); Smith (1); Jackson (2); Pike (1); Perry (1).

Thamnophis sauritus sauritus Linnaeus.—One specimen, from Brooklyn, yields the following information: subcaudals 13+; ventrals 160; scale rows 19; supralabials 7-7; infralabials 11-11; postoculars 3-3; preoculars 1-1; anterior temporals 1-1; posterior temporals 2-2; length of body 42 cm. A male, from Red Creek, NW. Jackson County, has a total length of 495 mm, and a tail length of 195 mm. A female, from Ramsey Springs, SE. Stone Co., has a total length of 640 mm, and a tail length of 205 mm. Two additional specimens are from Hazlehurst, Copiah Co., and Ruth, Lincoln Co.

Thamnophis sauritus proximus Say.—One specimen is present from Hancock Co. Another is from nearby St. Tammany Parish, Louisiana.

Tantilla coronata coronata Baird and Girard.—Two specimens are present from 10 mi. S. Hattiesburg. Lengths are 260 and 215 mm; tail lengths are 50 mm in each. One specimen has the following data: ventrals 139; preoculars 1-1; postoculars 2-2; anterior temporals 1-1; posterior temporals 2-2; loreals, none.

Micrurus fulvius fulvius Linnaeus.—Four specimens: 3 mi. SSE. Brooklyn, at Ashe Forest Nursery (1); Brooklyn (1); NE. Stone Co. (1); 12 mi. W. Purvis, Lamar Co. (1). One specimen is too damaged for scale counts.

Data for the Brooklyn and Stone Co. specimens are as follows: subcaudals 31 and 30; ventrals 216 and 220; subcaudals/ventrals ratio .139 and .136; scale rows 15; supralabials 11-10 and 6-7; infralabials 11-10 and ?; length 46 and 58 cm.

Agkistrodon contortrix contortrix Linnaeus.—The collection contains one specimen from 8 mi. S. Meridian, Lauderdale Co. Data are as follows: subcaudals 44 (15 divided); ventrals 148; subcaudals/ventrals ratio .297; scale rows 23 at midbody; supralabials 8-8; infralabials 9-10; loreal 1-1; length 65 cm. Another specimen was observed DOR 12 mi. W. of Purvis, Lamar Co. Additional specimens: Hazlehurst (1), Wesson (1), Bahala Creek (1), all of Copiah Co.

Agkistrodon piscivorous leucostoma Troost.—Twenty specimens: Creeks and ponds at Brooklyn (10); 5 mi. NNW. Brooklyn (2); 5 mi. NW. Brooklyn (1); 10 mi. NW. Brooklyn (1); one mi. N. Brooklyn (1); 10 mi. E. Lumberton (1); Mississippi City, Harrison Co. (1); Yokena, Warren Co. (1); Bogue Chitto River, Lincoln Co. (1). Data available from 17 SE. Mississippi specimens are as follows: subcaudals 22-50 (41); ventrals 133-141 (136); subcaudals/ventrals ratio .164-.360 (.303); scale rows usually 25 (27 in one); supralabials usually 8-8; infralabials in all combinations from 9-9 to 11-11; loreals present in six specimens; lengths 22-90 (62) cm.

Sistrurus miliarius barbouri Gloyd.—One specimen from 5 mi. SE. Brooklyn, Perry Co. This subspecies intergrades with *S. m. streckeri* in this area.

Sistrurus miliarius streckeri Gloyd.—One specimen from 3 mi. SSE. Brooklyn. Scale counts are as follows: subcaudals 34; ventrals 127; supralabials 11-10; infralabials 11-10; scale rows at midbody 21; length 349 mm.

Crotalus adamanteus Beauvois.—Six specimens: Brooklyn (3); 2 mi. SW. Brooklyn (1); one mi. N. Brooklyn (1); 5 mi. NNW. Brooklyn (1). Subcaudals vary from 26-33 (29); ventrals vary from 166-177 (171); subcaudals/ventrals ratio .143-.197 (.173); scale rows 29; lengths vary from 84-157 (123) cm.

Crotalus horridus atricaudatus Latreille.—Two specimens: vicinity of Wanilla, Lawrence Co. (1); Yokena, Warren Co. (1). A living specimen was observed 5 mi. ESE. Columbia, Marion Co.

REFERENCES

CLIBURN, J. WILLIAM 1956—The taxonomic relations of the water snakes *Natrix taxispilota* and *rhombifera*. Herpetologica 12:198-200.

KLAUBER, L. M. 1956—*Agkistrodon* or *Ancistrodon?* Copeia 1956:258-259.

NEILL, WILFRED T. 1954—Ranges and taxonomic allocations of amphibians and reptiles in the southeastern United States. Publ. Res. Div. Ross Allen's Rept. Inst. 1:86-90.

SCHMIDT, K. P. 1953—A checklist of North American amphibians and reptiles. 6th ed. Univ. of Chicago Press, Chicago, Ill.

WRIGHT, A. H. AND A. A. WRIGHT 1952—List of the snakes of the United States and Canada by states and provinces. Amer. Midl. Nat. 48:574-603.

A Natural Hybrid Between Black and White Spruce in Minnesota

ELBERT L. LITTLE, JR., AND SCOTT S. PAULEY[1]

A natural hybrid tree between black spruce (*Picea mariana* (Mill.) B. S. P.) and white spruce (*P. glauca* (Moench) Voss) was discovered near Cromwell, Minn., in 1955. This is the first report of such a cross, although the two species have broad, almost identical ranges from Newfoundland and northeastern United States across Canada to Alaska. The interspecific cross may be designated by the formula *Picea glauca* × *mariana*, rather than a binary name. The Minnesota variation, which may be useful in the spruce improvement program, is described and is given the variety (cultivar) name Rosendahl spruce.

Review of Literature

Johnson (1939) and Richens (1946) did not report natural hybrids between black and white spruce. In a summary of species crossability in spruce, Wright (1955) reported that these two species do not cross naturally to any extent, if at all. He cited unsuccessful attempts by Eklundh (1943) and by C. Heimburger in Canada to produce this hybrid artificially. In a preliminary report Johnson and Heimburger (1946) listed this interspecific cross with 379 seedlings and 73 percent survival. Wright (1955) pollinated 13 ovulate strobili of 2 white spruces with pollen from 1 black spruce and reported a probably or possibly successful cross in 1 parent combination in which 7 cones matured with an average of 5 filled seeds per cone. The reciprocal cross was a failure: the 60 ovulate strobili on 1 black spruce pollinated from 6 white spruce matured no cones.

Two other species hybridize with white spruce where the ranges meet. The cross with Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in southern Alaska was designated as Lutz spruce by Little (1953). Intergrades between white spruce and Engelmann spruce (*P. engelmannii* Parry) are common in British Columbia and have been studied in detail by Garman (1953, 1957). Material of the cross between black spruce and red spruce (*P. rubens* Sarg.) has been sent for study by Mark Holst, Petawawa Forest Experiment Station, Chalk River, Ontario.

Picea mariana and *P. glauca* differ in many ways, although they are commonly considered to be closely related species. For example, Rehder (1940) and Lacassagne (1934) placed them near each other under Sect. *Eupicea* Willk. Wright, however, found no natural break

[1] The authors are, respectively, Dendrologist, Division of Forest Management, Forest Service, U.S. Department of Agriculture, Washington, D. C., and Professor, School of Forestry, University of Minnesota, St. Paul, Minn.

in the genus sufficient to warrant the erection of section lines but placed the two species in different groups. In a comprehensive summary table comparing 31 species of *Picea* on 51 morphological characters, Wright (1955, Table 3) showed these 2 species to differ in 27 characters or, by a weighted basis, in 19 units. Thus, he classed the two as morphologically distinct species with greatly overlapping ranges. Earlier, LeBarron (1948) tabulated several other differences including crown form, bark, and seedlings.

DISCOVERY AND IDENTIFICATION

The hybrid tree described here was discovered by Elmer Homstad, ranger of Minnesota Department of Conservation, on August 18, 1955, when he was collecting white spruce cones from trees located on the property of Martin Stoner, near the village of Cromwell (altitude 1,300 feet), Carlton County, northeastern Minnesota, about 30 miles west of Duluth. He noted that cones from this tree differed markedly from those on other trees, and he collected a small sample. On August 25 he showed several of the odd cones to John Childs, Nursery and Planting coordinator at General Andrews State Nursery, Minnesota Department of Conservation. Mr. Childs, who had never before seen cones like these in working with spruce cones for 24 years, concluded that they were either from a hybrid between white and black spruce, or from an unfamiliar species. He sent a sample to the School of Forestry, University of Minnesota. Scott S. Pauley collected botanical specimens on October 11, 1955, and May 18, 1956.

The identification was made by various workers, including Dr. Carl Otto Rosendahl (1875-1956), late professor emeritus, Department of Botany, University of Minnesota. In recognition of his many contributions to a better knowledge of the plants of Minnesota, the hybrid is named in his honor.

The formula *Picea glauca* × *mariana* will serve to designate all recognizable hybrids, both natural and artificial, between these two parent species. As a binary name seems neither useful nor necessary, no Latin name is given to this interspecific hybrid. Most workers in forest tree improvement programs in the United States prefer the formulas and oppose giving additional Latin names to tree hybrids. The variety (cultivar) name Rosendahl spruce is to be associated with this Minnesota hybrid to distinguish it from any other variations from the same parent species, such as from other areas, that may be named later.

BOTANICAL DESCRIPTION

Rosendahl spruce (Figs. 1-3, Table I) **Picea glauca × mariana.**

Natural hybrid tree with twigs, buds, leaves, and cones intermediate between *Picea glauca* (Moench) Voss (Deut. Dendrol. Gesell. Mitt. 16:93. 1907 [1908]) and *Picea mariana* (Mill.) B. S. P. (Prel. Cat. Anth. Pter. N. Y. 71. 1888). Twigs light brown, becoming dark brown, slightly puberulent to glabrous; pulvini elongate, slightly rounded and raised; sterigmata about 1 mm

long. Buds ovoid, 3-6 mm long, light reddish brown, scales mostly appressed and obtuse, puberulent, ciliate; terminal buds with basal ring of subulate scales. Leaves radially arranged and spreading slightly toward twig apex on all sides, linear, 10-13 mm long, about 1 mm broad, nearly 1 mm thick, blue green, 4-angled, acute at apex, upper (adaxial) surface with mostly 4-5 (-6) rows of stomata on each side and lower (abaxial) surface with mostly 2-3 (-4) rows

TABLE I.—Comparison of the three adjacent trees of black spruce (*Picea mariana*), Rosendahl spruce (*P. glauca* × *mariana*), and white spruce (*P. glauca*). Characters of Rosendahl spruce are indicated as intermediate (I), like *P. mariana* (M), like *P. glauca* (G), or different (D).

Character	*Picea mariana* black spruce	*Picea glauca* × *mariana* Rosendahl spruce	*Picea glauca* white spruce
Bark:			
Surface	rough, abundant scales	smoothish, very few scales (G)	smoothish, very few scales
Color of freshly exposed surface	greenish yellow	pinkish (G)	pinkish
Branches:			
Number	more per whorl	fewer (G)	fewer
Length	relatively short	long (G)	long
Diameter	relatively thin	thick (G)	thick
Persistence	long persistent	less persistent (G)	less persistent
Layering	present	absent (G)	absent
Twigs:			
Diameter	1-2 mm	2-3 mm (G)	2-3 mm
Color	dark reddish brown to blackish	light to dark brown (I)	light yellow brown
Surface	puberulent	slightly puberulent to glabrous (I)	glabrous
Pulvini	flattened	slightly rounded and raised (I)	rounded and raised
Aphid galls	numerous	none (G)	none
Buds:			
Length	3-5 mm	3-6 mm (I)	5-7 mm.
Color	light reddish brown	light reddish brown (M)	light brown
Apex	acute	obtuse to acute (I)	obtuse
Bud scales:			
Position	appressed	mostly appressed (I)	slightly spreading
Apex	acute	mostly obtuse (I)	obtuse
Apex of basal scales	subulate	acuminate to subulate (I)	acute
Surface	puberulent	glabrous to puberulent (I)	glabrous
Leaves:			
Length	8-12 mm	10-13 mm (I)	15-21 mm
Apex	acute to obtuse	acute (I)	acuminate to acute

TABLE I.—(Continued).

Character	*Picea mariana* black spruce	*Picea glauca* × *mariana* Rosendahl spruce	*Picea glauca* white spruce
Color	blue green	slightly lighter blue green (D)	blue green
Odor	resinous	resinous	skunklike
Stomata rows on each upper (adaxial side)	4-5 (-6)	4-5 (-6) (M)	2-4
Stomata rows on each lower (abaxial) side	2 (1-3)	2-3 (-4) (G)	2-4
Resin sacs or canals	2, long	usually 2, short (I)	usually 0
Cones:			
Location	top of crown	through crown (G)	through crown
Stalk	5 mm long, stout, curved	short, slightly curved (I)	very short
Length	2-2.5 cm	3.5-4.5 cm (I)	4-5.5 cm
Width closed	1.5-1.8 cm	1.2-1.5 cm (I)	1.0-1.3 cm
Width open	2-2.5 cm	2.5-3 cm (D)	2-2.5 cm
Shape	ovoid	oblong-ovoid (I)	oblong-cylindric
Color (immature)	dark purple	dark purple (M)	yellow green
Color (mature)	brown to dark brown	brown (G)	brown
Persistence	2 or more years	less than 1 year (G)	less than 1 year
Cone scales:			
Surface (immature)	not resinous or sticky	resinous, sticky (G)	resinous, sticky
Surface	shiny	shiny (M)	dull
Apex	rounded	nearly truncate (I)	truncate
Margin	denticulate	slightly denticulate (I)	almost entire
Texture	rigid	flexible-rigid (I)	flexible
Bract, shape	rounded	oblong (G)	oblong
Bract, length	2 mm long	4-5 mm long (I)	5-6 mm long
Bract, color	reddish brown	reddish brown (M)	light brown
Seeds:			
Length including wing	7 mm	10-12 mm (G)	11-12 mm
Color of wing	brown	brown (M)	light brown
Ovulate strobili at pollination:			
Length	(10+ mm)	20 mm (I)	23 mm
Shape	ovoid (?)	oblong-ovoid (I)	oblong-cylindric
Staminate strobili:			
Length	10 mm	20 mm (G)	20 mm
Shape	ovoid-cylindric	oblong-cylindric (G)	oblong-cylindric
Pollination time:	late	intermediate (I)	early

on each side; resin sacs or canals usually 2, short, mostly 2-5 (1-7) mm long, in cross section 2, 1, or 0.

Cones on short curved stalk, oblong-ovoid, 3.5-4.5 cm long, 1.5 cm broad when closed, 2-2.5 cm broad when open; scales obovate, 12-14 mm long, 8-9 mm broad, truncate and slightly denticulate at apex, thin and flexible, puberulent, the exposed portion mostly dark purple or blackish, bracts oblong, 4 mm long and 2-2.5 mm broad, reddish brown, obtuse and slightly denticulate at apex; seeds 10-12 mm long, including ovoid blackish body 3 mm long and thin obovate brown wing. Ovulate strobili when receptive oblong-ovoid, 20 mm long. Staminate strobili oblong-cylindric, 20 mm long.

The following specimens from the type of tree of Rosendahl spruce (*Picea glauca* × *mariana*) near Cromwell, Carlton County, Minn., may be cited: *Scott S. Pauley, May 18, 1956* (type collection), *October 11, 1955, May 26, 1956* (ovulate strobili and staminate strobili at pollination), *August 24, 1956* (cones); *Elmer Homstad, September 1955* (cones). Holotype deposited in National Herbarium, U. S. National Museum. Isotypes at herbaria of U. S. Forest Service, University of Minnesota, Harvard University (Gray), New York Botanical Garden, Chicago Natural History Museum, Bailey Hortorium of Cornell University, and Yale University.

Type specimens were prepared by immersion in boiling water 10 minutes to retain the needles (Little, 1952). Additional material was pressed and mounted on cotton sheets with transparent plastic cover sheets stapled securely, as described by Reeder (1955), to show stomata lines and natural color.

COMPARISON WITH PARENTS

The type tree of Rosendahl spruce is growing on well-drained upland soil, in mixture with white spruce, eastern white pine (*Pinus strobus* L.), and black spruce, and is flanked and touched by one tree of each of the two parent species (Fig. 1). When discovered, this hybrid tree was 32 years old, 26 feet tall (estimated), and 11.7 inches d. b. h. The adjacent black spruce was 36 years old, 26 feet tall (estimated), and 7.0 inches d. b. h., and the white spruce on the other side was 28 years old, 24 feet tall (estimated), and 10.8 inches d. b. h. In crown shape the tree resembles white spruce. Though several basal branches of the hybrid were resting on the ground, no rooting had taken place. The black spruce, however, had a well-developed propagule as a result of layering.

Rosendahl spruce probably is a first generation hybrid because it is intermediate in numerous ways between the two adjacent trees of the parent species. For example, leaves and cones are longer than in black spruce but shorter than in white spruce (Figs. 2 and 3).

Table I compares the 3 trees on 50 characters in which the 2 parent species differ. It is adapted from Wright (1955, Table 3) with various modifications and with the hybrid added. Characters common to both parent species are omitted. According to Table I, Rosendahl spruce is intermediate in 23 of the 50 characters, like

Fig. 1.—Tree of parent species and hybrid, near Cromwell, Minn. Left, black spruce (*Picea mariana*); center, type tree of Rosendahl spruce (*P. glauca* × *mariana*); and right, white spruce (*P. glauca*). October 11, 1955.

white spruce in 18, like black spruce in 7, and different from both species in 2 characters.

The hybrid and parents may be compared further by means of the Hybrid Index (Anderson, 1949). Each of the 50 characters in Table I is scored 0, if like black spruce, 1, if intermediate, and 2, if like white spruce. Total score of the hybrid is 61, intermediate but slightly nearer to white spruce (100) than to black spruce (0).

For several characters, Rosendahl spruce resembles one parent species more than the other. The dark purple cone color, like black spruce, made the cones conspicuous and led to the discovery. Cone scales are shiny, as in that species, but are resinous and sticky before maturity, as in white spruce. Bracts of cone scales combine the oblong shape of white spruce and the reddish brown color of black spruce. Terminal buds have the basal ring of subulate scales, as in black spruce, but less developed.

In branching characteristics, the hybrid tree is like white spruce. Black spruce has more lateral branches in a whorl and is difficult for climbing. Dead branches all along the axis as well as live branches with persistent cones in the upper crown remain on the tree for a long time. White spruce and the hybrid have fewer and less persistent lateral branches.

Of the three individuals growing together, the black spruce has numerous aphid galls, probably caused by the pine leaf aphid (*Pineus pinifoliae* (Fitch)). These galls do not occur on the hybrid, which has branches interlaced with the black spruce, or on the white spruce. Black spruce is one of the host species listed for this aphid (Craighead, 1950), but white spruce is not.

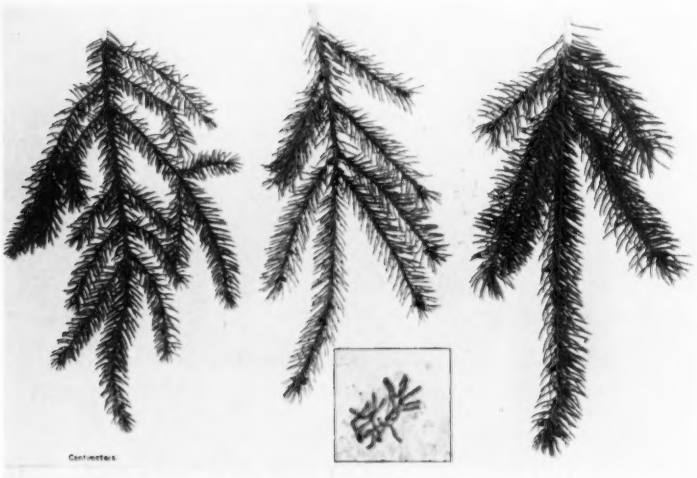


Fig. 2.—Leafy twigs: Left, black spruce (*Picea mariana*); center, Rosendahl spruce (*P. glauca* × *mariana*); and right, white spruce (*P. glauca*), about ¼ natural size. Inset, photomicrograph, showing 12 chromosomes (n) at metaphase in female gametophyte tissue of Rosendahl spruce, about 490×.

Rosendahl spruce differs from both adjacent trees in two characters, width of open cone and foliage color. Width of the open cone, greatest in the hybrid (Fig. 3), apparently is the result of combination of characters for cone size and shape. The foliage of the hybrid is slightly lighter blue green than in either parent species. Apparently this color is associated with the slightly larger number of whitish stomata rows or lines in the needles of the hybrid, the larger number on the upper surface of black spruce needles combined with the larger number on the lower surface of white spruce needles.

A preliminary comparison of resin sacs or canals of leaves in the three trees was made because the number and position vary within the genus *Picea* and may be of some taxonomic significance (Wright, 1955, Table 3). Marco (1931) and Reed and Freytag (1949) observed that resin sacs or canals in Engelmann spruce and blue spruce (*P. pungens* Engelm.) are a longitudinal series of cavities as compared with the continuous canals in *Pinus*. White spruce normally has no resin sacs in the leaves, rarely 1 or 2. The white spruce adjacent to Rosendahl spruce rarely had 1 or 2 short resin sacs in the leaves. Black spruce has 2 resin sacs or canals continuous from base to apex of the leaf, near the abaxial surface, external or marginal (rarely slightly medial), 1 beyond or outside the rows of stomata on each side and visible from the surface under low magnification.

Leaves of Rosendahl spruce, according to a preliminary examination of dried material with a low-power dissecting microscope, have 2 (rarely 1) short resin sacs, mostly 2-5 mm long (sometimes only 1 mm or up to 7 mm), 1 on each side, mostly in the basal or middle third or infrequently in the apical third. In a cross section, 2, 1, or no resin sacs may be visible under a compound microscope, because these short tubes are not uniformly placed. Thus, the hybrid is intermediate in having 2 short resin canals.

Gordon (1952) noted a twig character for separating black spruce from white spruce as well as red spruce. In black spruce the pulvini or decurrent ridges at the base of each leaf are flattened, forming a nearly flat cylinder in twig cross section, but in white spruce the pulvini are rounded and raised. The hybrid is intermediate, with ridges slightly rounded but raised less than in white spruce.

Chromosome number (n or haploid) of Rosendahl spruce was determined from female gametophyte tissue to be 12, as shown in Figure 2, inset. Sax and Sax (1933 recorded this same number for both parent species. This number is characteristic of many conifers.

About ¼ bushel of cones was yielded by the hybrid tree in 1955, but only about 3 percent of the seed was good. Seedlings from this hybrid are variable and will be studied further. Controlled pollination, including both selfings and backcrossings, is being undertaken for genetic investigations.

Fig. 3.—Unopened cones, opened cones, and seeds: Left, black spruce (*Picea mariana*); center, Rosendahl spruce (*P. glauca* × *mariana*); and right, white spruce (*P. glauca*), about ⅜ natural size.

In 1956, which had a spring about 2 weeks late, the dates of pollen maturity and receptivity of the 3 adjacent trees occurred during the last week in May and first 2 or 3 days in June. The white spruce was first, the hybrid next, and the black spruce last, but cross pollinations between all three were possible in this perhaps abnormal spring. Frequency of aborted pollen grains was low in all three trees.

The hybrid is located near the southwestern limit of range of both species. Natural hybrids of trees often occur near the limits of ranges of the parent species. Apparently crossing between these two species with the same broad distribution is infrequent. Otherwise, the two would not remain distinct.

REFERENCES

ANDERSON, EDGAR 1949—Introgressive hybridization. 109 pp., illus. New York.

CRAIGHEAD, F. C. 1950—Insect enemies of eastern forests. U. S. Dep. Agric. Misc. Publ. 657. 679 pp., illus.

EKLUNDH, CARIN 1943—Artkorsningar inom sl. Abies, Pseudotsuga, Picea, Larix, Pinus och Chamaecyparis, tillhörande fam. Pinaceae. [Species crosses within the genera Abies, Pseudotsuga, Picea, Larix, Pinus, and Chamaecyparis, belonging to the family Pinaceae.] Svensk PappTidn. 46:55-61, 101-105, 130-133. 1943. (Not seen; abstract in For. Abs. 5:95-96. 1943.)

GARMAN, E. H. 1953—Pocket guide to the trees and shrubs of British Columbia. For. Serv. Brit. Columbia Publ. B28. 102 pp., map. Ed. 2.

———1957—The occurrence of spruce in the interior of British Columbia. For. Serv. Brit. Columbia Tech. Publ. T. 49. 31 pp., illus.

GORDON, A. G. 1952—Spruce identification by twig characteristics. For. Chron. 28(3):43-45, illus.

JOHNSON, L. P. V. 1939—A descriptive list of natural and artificial interspecific hybrids in North American forest-tree genera. Canad. J. Res. C. 17:411-444.

——— AND C. HEIMBURGER 1946—Preliminary report on interspecific hybridization in forest trees. Canad. J. Res. C. 24:308-312.

LACASSAGNE, MARCEL 1934—Étude morphologique, anatomique et systématique du genre Picea. Trav. Lab. For. Toulouse, tome 2, v. 3, art. 1, 292 pp., illus.

LEBARRON, RUSSELL K. 1948—Silvicultural management of black spruce in Minnesota. U. S. Dep. Agric. Circ. 791. 60 pp., illus.

LITTLE, ELBERT L., JR. 1952—Preparing specimens of Picea and Tsuga. Rhodora 54:232-234.

———1953—A natural hybrid spruce in Alaska. J. For. 51:745-747.

MARCO, H. F. 1931—Needle structure as an aid in distinguishing Colorado blue spruce from Engelmann spruce. Bot. Gaz. 92:446-449, illus.

REED, JOHN F. AND GEORGE F. FREYTAG 1949—The resin sac pattern in the needles of Engelmann spruce and blue spruce from southeastern Wyoming. Amer. Midl. Nat. 41:233-236.

REEDER, JOHN R. 1955—Another method for preparing herbarium specimens of Picea and Tsuga. Trop. Woods 102:46-48, illus.

REHDER, ALFRED 1940—Manual of cultivated trees and shrubs hardy in North America. Ed. 2. 996 pp., map. New York.

RICHENS, R. H. 1946—Forest tree breeding and genetics. Imp. Agric. Bur. [Gt. Brit.] Joint Publ. 8. 79 pp.

SAX, KARL AND H. J. SAX 1933—Chromosome number and morphology in the conifers. J. Arnold Arbor. 14:356-375, illus.

WRIGHT, JONATHAN W. 1955—Species crossability in spruce in relation to distribution and taxonomy. For. Sci. 1:319-349, illus.

The Larger Plants of Little Kitoi Lake

ROBERT E. VINCENT[1]
Alaska Department of Fish and Game

Little Kitoi Lake is located on Afognak Island, Alaska, near the northern fringe of the marine west coast climatic region. A uniformly cool temperature and a well-distributed annual precipitation of 56 inches characterize the climate of the island (Fig. 1). The frost free growing period is 100 days. Mean annual cloudiness is near 70 percent (Bartholomew 1942).

A shallow soil with frequent rock outcroppings and a four- to eight-inch layer of pumice are the salient edaphic features. Ekman dredge samples from the bottom of Little Kitoi Lake indicate that little organic matter has settled on the nearly inert pumice layer, which was deposited in 1912 by an eruption of Mount Katmai.

[1] Present address: Department of Conservation, Cornell University.

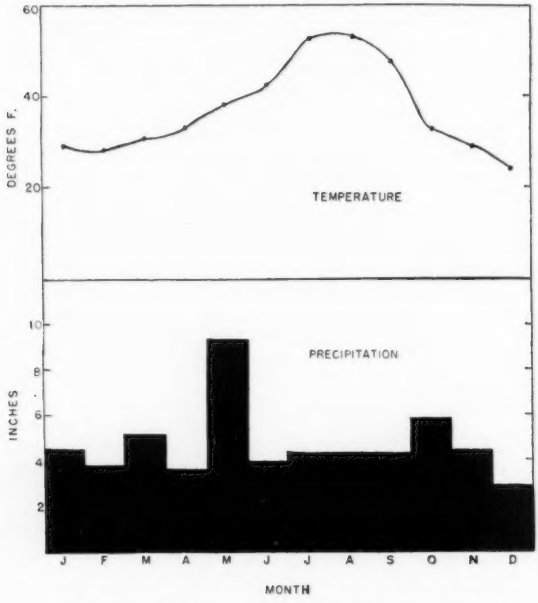


Fig. 1.—Annual temperature and precipitation of Afognak Island, Alaska.

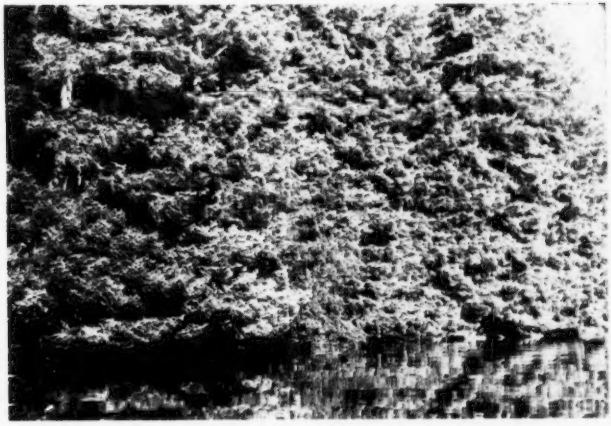


Fig. 2.—*Picea sitchensis* overhanging psammolittoral.

Erosion, either by the inlet streams or direct runoff is minimal; even lake wave erosion is reduced by the rocky shoreline.

Little Kitoi Lake is roughly elliptical with the long axis lying north and south. It contains approximately ninety surface acres. The basin lies 15 feet above sea level. It is of secondary glacial origin, which accounts for the generally smoothed shoreline. A small one-half-acre island is located near the northeast corner. Lake water level has a maximum fluctuation of 20 inches, and an ice and snow cover exists on the average of 5 months each winter.

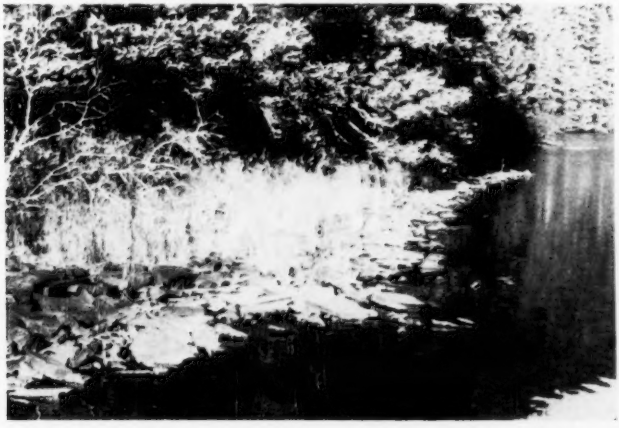


Fig. 3.—Rocky open beach, one of four beach habitats.

Acknowledgment.—Appreciation is extended to A. N. Steward, S. C. Head, and T. M. Barkley of Oregon State College for identifying many of the plants.

Picea sitchensis (Bong.) Carr. (Sitka spruce) with an understory of *Oplopanax horridum* (Sm.) Miquel (devil's club) and *Vaccinium ovalifolium* Smith (huckleberry) circumvallates the lake except for an open slope on the north shore. In the few small lake shore openings, *Rubus spectabilis* Pursh (salmonberry), *Sambucus racemosa* L. (red elderberry), and *Alnus sinuata* (Regel) Rydb. (mountain alder) are sparsely distributed. Proximity of *P. sitchensis* to the psammolittoral region is contingent upon the shore configuration. The boughs overhang the complete psammolittoral in many places (Fig. 2), while in other areas of less gradient only the outer beach (Welch, 1952) is canopied. In the latter situation marginal terrestrial plants may invade both the outer and middle (Welch, *ibid.*) beaches, depending upon the substratum and exposure. Although narrow and sparsely vegetated, these beaches may be divided into four habitat types: rocky open (Fig. 3), rocky shaded, sand humus open, and sand humus shaded. The common plant species inhabiting the beach habitats are as follows:

Rocky Open

Hordeum brachyantherum Nevski (barley)
Deschampsia beringensis Hulten (hair-grass)
Agrostis exarata Linn. (bent-grass)
Rumex fenestratus Greene (dock)
Dodecatheon sp. (shooting star)

Rocky Shaded

Epilobium lactiflorum Hausskn. (willow-herb)
Arnica chamissonis Less. (arnica)
Aster foliaceous Lindl. ex DC. (aster)

Sand Humus Open

Calamagrostis canadensis (Michx.) Beauv. (blue-joint)
Phleum alpinum Linn. (mountain timothy)
Potentilla anserina Linn. (cinquefoil)
Heracleum lanatum Michx. (cow parsnip)

Sand Humus Shaded

Geum macrophyllum Willd. (avens)
Sanguisorba sitchensis C. A. Mey. (burnet)
Angelica sp.
Artemisia tilesii Ledeb.
Habenaria dilatata Hook. (bog orchid)

The perimeter, deltas, and small coves are the three general regions within the lake which provide a muddy substratum in shallow water for the growth of hydrophytes. The lake perimeter is a narrow, discontinuous band around the lake shore delimited by wave-swept shoals shoreward (Fig. 4) and by water depth lakeward. Varying with the beach slope, this area is located between 5-25 feet from the shore waterline. A shallow substratum of wave-carried silt and allochthonous organic materials has been deposited. Since this zone is subject to strong wave action, all plants are submerged species. Nowhere in

Fig. 4.—Wave-swept shoals beneath ten inches of water.

the lake perimeter is the vegetative mass dense but, rather, consists of a loose assemblage of open patches. The aquatic plant species occupying the perimeter include:

Isoetes Braunii Durieu (quillwort)
Potamogeton alpinus Balbis var. *tenuifolius* (Raf.) Fernald
P. epihydrus Raf. (Nuttall's pondweed)
P. Richardsonii (A. Benn.) Rydb. (Richardson's pondweed)
P. sp. (pondweed)
Ranunculus confervoides Fr.

There are three deltas in the lake: two on the northeast shore and one on the west shore. The largest inlet stream enters at the deep west shore where the swiftly flowing water has deposited a gravel

Fig. 5.—Muskrat runway through *Carex* on a delta.

Fig. 6.—Succession on the northeast delta.

delta. Little silt remains on the delta due to action of alongshore currents and waves. Very few aquatic plants are present.

The largest single area of aquatic vegetation occurs in the remaining two deltas. The deltas are 100 yards apart in a protected, shallow bay. One of the streams is near base level, while the other has only a short, turbulent section; both are depositing a silt instead of gravel delta. A small island lies lakeward from the deltas sheltering them from much of the wave action and alongshore currents.

Fig. 7.—Submerged *Utricularia macrorhiza.*

Fig. 8.—*Nuphar polysepalum*, characteristic of sandy, humus beach areas.

Hydrophytes found on these deltas (listed from shallow to deeper water) are:

Galium trifidum Linn. (bedstraw)
Carex sp. (sedge)
Juncus filiformis Linn. (thread rush)
Hippuris vulgaris Linn. (marestail)
Equisetum limosum Linn. (swamp horsetail)
Utricularia macrorhiza LeConte (bladderwort)

As the marshy sedge delta hydrosere becomes dryer, the dominating *Carex* (Fig. 5) and *Juncus* are replaced by grasses *Calamagrostis canadensis* and *Phleum alpinum*, which then give way to the hydrophytic woodland species, *Alnus sinuata* and *Salix* sp. (Fig. 6).

Five small coves support the most diversified aquatic flora within the lake. With the strongest winds blowing from the north and west, coves usually have a southerly and easterly exposure. A sandy, humus beach extending from the inner beach to the sublittoral provides a

Fig. 9.—*Sparganium angustifolium* growing in a small cove.

substratum for submerged (Fig. 7) and floating species (Fig. 8, 9), as well as shallow marsh for a small sedge meadow. The following hydrophytes, listed in order of occurrence from shallow to deeper water, are found in coves:

Caltha palustris L. (marsh marigold)
Galium trifidum Linn.
Carex sp.
Juncus filiformis Linn.
Juncus sp.
Rorippa palustris (Linn.) Moench (marsh cress)
Hippuris vulgaris Linn.
Equisetum limosum Linn.
Equisetum sp.
Sparganium angustifolium Michx. (narrow-leaved bur-reed)
Ranunculus sp.
Nuphar polysepalum Engelm. (yellow pond-lily)

REFERENCES

BARTHOLOMEW, JOHN 1942—*The Oxford Advanced Atlas.* Oxford University Press, Oxford. 32 pp.

WELCH, P. S. 1952—Limnology. McGraw-Hill Book Company, Inc., New York. 538 pp.

Notes on Mammals of Southern Illinois

JAMES N. LAYNE
University of Florida, Gainesville, Florida

Natural habitats in southern Illinois are more varied than elsewhere in the state, and this is reflected in a relatively rich mammalian fauna. However, surprisingly little concerning the biology of the mammals of this region has been recorded, most of the pertinent literature being of a taxonomic or distributional nature. The present paper is based on observations and collections made during the period from July, 1954, through June, 1955, and is intended primarily as a contribution to a specific knowledge of the natural history of the mammals of southern Illinois.

Data were gathered from 14 counties (Fig. 1). Twelve of these are within the group of 16 southernmost countries of Illinois commonly denoted as Southern Illinois, while two (Jefferson and Marion) lie to the north. Nearly 900 specimens of 37 species were examined, and observations were made on five additional species of which no specimens were taken. Approximately 400 skins and skulls were prepared. In addition, many skulls without skins and other skeletal materials were saved. A number of bats were preserved in 70 percent alcohol, while many carcasses, reproductive organs, and alimentary tracts of various species were preserved in 10 percent formalin for further study. These materials have been deposited in the Wildlife Research Laboratory collection, Southern Illinois University, and the University of Florida mammal collection.

Description of the Area

While most of Illinois lies in the Central Lowlands Province, three other physiographic provinces, the Interior Low Plateaus, Ozark Plateaus, and Coastal Plain, are represented in the southern portion of the state (Fig. 1). The limits of these major physiographic regions and their subdivisions in Illinois have been defined by Leighton *et al.* (1948).

The southernmost extension of the Central Lowlands Province in the state is the Mount Vernon Hill Country, a region characterized by low relief and broad stream valleys. The soils of the uplands are of medium to low productivity. Approximately 16 percent of the land is wooded (King and Winters, 1952), with stands being composed chiefly of mixed oaks, elm, hickories, soft maple, and ash. Except for farm woodlots, the principal forest tracts occur in the bottomlands or areas of particularly rugged topography where cultivation is not feasible.

The Interior Low Plateaus Province is represented in Illinois by the Shawnee Hills Section, a region lying between the Central Lowlands to the north and the Coastal Plain Province to the south and

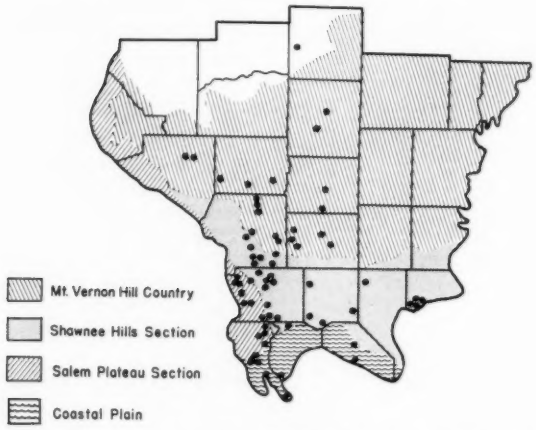


Fig. 1.—Map of southern Illinois showing the principal physiographic divisions recognized by Leighton *et al.* (1948) and the localities where collections or observations were made.

including part or all of 12 counties. The Shawnee Hills, or "Illinois Ozarks," form a continuous ridge across the lower end of the state of rather rough, rolling, dissected uplands with numerous steep hillsides and bluffs. The highest point, 1,065 feet, is situated in Pope County. Karst features are present in limestone formations in Hardin and Union counties. The northern boundary of this division marks the approximate southernmost limit of glaciation in Illinois.

The Ozark Plateaus Province extends into the state along the southwestern edge. Two subdivisions are recognized, the southern one being the Salem Plateau Section. The lower portion of the latter is distinguished from the adjoining Shawnee Hills by a more rugged topography and higher average elevation. The drainage pattern is markedly dendritic, the secondary tributaries occupying youthful valleys while the larger watercourses are alluviated. The Mississippi River borders this region, actually bisecting it at one point. In Jackson and Union counties the floodplain of the Mississippi averages from five to seven miles across and meets the uplands abruptly in a line of high, rocky bluffs and steep hillsides. Although the floodplain has been extensively drained and cultivated, large tracts of swampy woodlands, shallow ponds bordered by dense vegetation, and rank, swale-like areas still persist. The common trees in the lowlands include pecan, sycamore, ash, elm, hackberry, honey locust, cottonwood, and pin and other water-tolerant oaks. On the uplands mixed oaks and hickories predominate, with American beech occurring in certain suitable sites.

The Shawnee Hills and Salem Plateau Section together form the

most extensively forested area in Illinois. Twenty-six percent of the land area is estimated to be wooded (King and Winters, 1952). Several species of vascular plants are peculiar to this part of the state (Jones, 1950). These include *Polypodium polypodiodes, Pinus echinata, Ulmus alata, Magnolia acuminata,* and *Rhododendron roseum.*

The Coastal Plain Province extends only into the extreme tip of the state. Two major subdivisions are recognizable. Below the Shawnee Hills and Ozark Plateau region are the floodplains of the Mississippi and Cache rivers. Between these bottomlands and the Ohio River is interposed a low, maturely-eroded ridge of hills underlain by Cretaceous deposits. The lands at the tip of the state have been extensively diked and drained and much of the area is under cultivation. However, tracts of bottomland forests and marshy areas still remain, and seasonal fluctuations in water levels continue to be rather pronounced in some sites. The flora of this region includes a distinct Austroriparian element, as exemplified by the occurrence of such species as *Taxodium distichum, Arundinaria gigantea, Planera aquatica, Nyssa aquatica* and *Phorodendron flavescens.* Certain of these, such as bald cypress and mistletoe, extend a considerable distance northward in the river bottoms.

The climate of southern Illinois is characterized by comparatively hot, dry summers. Winters, though cool, are markedly less severe than in the northern part of the state. July temperatures average 78° F. or above (Page, 1949). Mean January temperatures are generally above freezing, as compared to averages of 26° F. or less in northern Illinois. The average number of frost-free days ranges from 185 to 213 in southern Illinois and from 150 to 190 over the remainder of the state. Annual precipitation varies from 38 to over 46 inches, snowfall accounting for a much lesser percentage of annual moisture than elsewhere in the state. Although precipitation tends to be fairly uniformly distributed throughout the year, winter and heavy spring rains are frequent and droughty conditions often prevail during the summer months.

ACKNOWLEDGMENT.—The field work upon which this report is based was performed while the writer was a member of the staffs of the Wildlife Research Laboratory and Department of Zoology, Southern Illinois University. The work was supported by a special research grant from the Graduate School. Sincere appreciation is expressed to the many persons who aided in field work, contributed specimens or observations, or helped in other ways. Chief among these are Dr. W. D. Klimstra, F. B. White, E. Stadelbacher, R. Shoop, R. Yates, D. Howell and B. J. Verts. Others include G. Gunning, E. Triner, R. Bell, J. Warnock, W. Steiglitz, J. Heaman, and K. Hill. Dr. Robert M. DeWitt, Department of Biology, University of Florida, kindly identified the snails found in cheek pouches of chipmunks, and Miss Esther Coogle aided in the preparation of Fig. 1. Dr. Donald F. Hoffmeister, Museum of Natural History, University of Illinois, read the manuscript and offered valuable suggestions.

SPECIES ACCOUNTS

Detailed studies of geographic variation will be needed before the subspecific status of a number of the mammals occurring in southern Illinois can be accurately stated. Consequently, an effort has been made to avoid an uncritical use of the trinomen in the accounts which follow. When available, data relating to the possible affinities of the population in question are briefly discussed in those cases where the subspecific name is omitted.

Didelphis marsupialis virginiana Kerr. Opossum. — The opossum is generally distributed throughout southern Illinois and is common in a variety of habitats.

Two males collected January 30 and March 15 contained abundant sperm in the epididymides. A female taken April 1 had six young in the pouch. Their average weight was 6.7 gms. Three young, ranging from 31.2 to 33.0 gms, were discovered crawling about a road-killed female on September 18.

Stomach contents of six specimens included earthworms, slugs, crayfish, insects (Coleoptera, Orthoptera, Hemiptera, and Lepidoptera), mole hair, unidentified mammal hair and flesh, corn, and miscellaneous plant fragments.

Measurements of four adults were: total length, 777.2 mm (771 - 840); tail, 301.8 mm (304 - 320); hind foot, 67.5 mm (62 - 71). Five adults ranged from 4 lbs. 2 oz. to 7 lbs. in weight.

Six specimens were collected at the following localities: Jackson Co.—Carbondale (1); Randolph Co.—4 miles W of Sparta (1); Union Co.—4 miles S of Jonesboro (1), Cobden (2); Williamson Co.—5 miles E of Marion (1). Tracks, living individuals, or road kills were observed in Franklin Co.—DeSoto; Perry Co.—Pyatt; Union Co.—3 miles SE of Ware; and Williamson Co.—Dog Walk.

Blarina brevicauda carolinensis (Bachman). Short-tailed shrew. — Specimens were trapped in surface runways in a variety of grassy situations and in subsurface burrows in mature oak-hickory woodlands.

Three males taken on April 3 were fertile. Males trapped in May and July were not in breeding condition. The tubal genitalia of a female obtained January 9 were noticeably swollen. Another taken on April 3 contained three fetuses measuring 11 mm in crown-rump length.

Average measurements and weights of 15 (7 males, 7 females, 1 sex unknown) fully-grown shrews were: total length, 95.0 mm (84 - 102); tail, 20.9 mm (19 - 25); hind foot, 11.7 mm (10 - 12); weight, 9.6 gms (7.8 - 12.8).

Sixteen specimens were collected at the following localities: Alexander Co.—½ mile NNW of Olive Branch (1), 3 miles NNW of Olive Branch (3), Tamms (5); Jackson Co.—Carbondale (2); Perry Co.—Pyatt (1); Pope Co.—½ mile NE of McCormick (1); Union Co.—Aldridge (2), 4 miles N of Cobden (1).

Cryptotis parva (Say). Least shrew. — Four specimens were col-

lected in Alexander Co., at Cache (2), 3 miles NW of Olive Branch (1), and Tamms (1). The shrews were trapped beneath an overhanging bank of a dry stream bed in a low-lying field of rank herbaceous vegetation and brush, in a moist surface runway in a brome sedge field, in an open runway in a dry, weedy field with sparse grass cover, and in a *Microtus* runway in heavy grass within a trumpet creeper thicket.

Two males, collected April 3 and 9, were in breeding condition. A female trapped October 30 showed slight enlargement of the uterine tubes and vagina but no evidence of placental scars or pregnancy. Her enlarged teats indicated that a litter had been previously suckled, although she was not lactating at the time of capture. A female trapped April 9 contained eight well-developed fetuses, averaging about 11 mm in crown-rump length.

Earthworms, insects, and undetermined arthropod remains were present in three stomachs examined.

As the subspecies of *Cryptotis parva* are presently understood, the form in southern Illinois appears to be *C. p. harlani*, as indicated by Hoffmeister and Mohr (1957). The validity of this subspecies appears somewhat questionable on the basis of the evidence thus far presented (Bole and Moulthrop, 1942).

Scalopus aquaticus machrinus (Rafinesque). Eastern mole.—Signs of this species were most frequently encountered in cultivated or fallow fields, lawns, and open woodlands. Fresh workings just below the ground surface were noted throughout the year.

Two males collected October 9 and 10 were not in breeding condition, whereas the cauda epididymal tubules of two specimens trapped January 25 and April 9 were engorged with sperm. The reproductive organs of two females obtained October 9 and January 9 showed no evidence of sexual activity.

Identifiable remains in the stomachs of two specimens consisted of adult and larval insects and plant fragments.

Mean measurements of four males were: total length, 181.5 mm (179 - 187); tail, 32.2 mm (26 - 39); hind foot, 22.4 mm (22 - 24). Similar measurements for two females were 165, 173; 28, 35; 20, 20. The weights of males varied from 102.6 to 126.5 gms, averaging 112.0, while the two females weighed 76.6 and 81.5 gms.

Seven moles were collected at the following localities: Alexander Co.—2 miles SE of Olive Branch (1); Jackson Co.—6 miles SW of Murphysboro (1), 7 miles SW of Murphysboro (1), Carbondale (4). Mole workings were also noted at the entrance to a cave about 2 miles N of Rosiclare, Hardin Co., on May 22.

Myotis lucifugus lucifugus (Le Conte). Little brown myotis.—Judging from the frequency with which they were collected, these bats are not particularly common in southern Illinois at any season. Hibernating specimens were collected in only five of the ten natural caves from which bats of various species were obtained. When present they occurred as isolated individuals or scattered small groups seldom

exceeding ten in number. No little brown myotis were noted in the eleven silica mines or prospect holes in which other species of bats were found. During the warmer months *Myotis lucifugus* was obtained at only one of five stations at which bats were collected by shooting. This site, at the edge of the Southern Illinois University campus, was within one-eighth of a mile of an active summer colony in the attic of a university building. At the place where the bats were collected during the evening flight, they appeared to be flying on a rather direct course from the daytime roost to a nearby lake.

Thirteen males and three females comprised the specimens collected at random in caves from November to March. Seven males and 23 females were killed during the evening flight in April and May. The sexes of the bats killed in June were more nearly balanced (4 males, 7 females). This correlates with the finding of Cagle and Cockrum (1943), who studied the colony of which these bats were probably members, that adult males suddenly appeared in considerable numbers in June.

Of 12 females examined between May 4 and 13, two showed no evidence of pregnancy, eight were gravid, and two had recently given birth to young. The gravid individuals exhibited a considerable range in the degree of development of their embryos. Two killed May 4 and 8 showed only slight enlargement of the right uterine horn. Five taken May 12 contained embryos varying in size from less than 1 mm in length to nearly full term. Eight specimens collected from May 26 to June 7 consisted of three animals carrying nearly term fetuses and five which had previously given birth to their young, although the uterine tubes were still markedly enlarged. The reproductive organs of an individual killed June 20 were nearly regressed to the non-breeding state.

Mean measurements of 16 adult males (tragus length available for only 13) were: total length, 89.1 mm (80 - 97); tail, 37.5 mm (34 - 40); hind foot, 8.6 mm (8 - 10); ear from notch, 14.0 mm (13 - 16); tragus, 7.1 mm (6 - 8); forearm, 36.3 mm (35 - 38). Six adult females averaged slightly smaller in all external measurements except forearm (ear and tragus lengths available for only five): total length, 85.8 mm (70 - 98); tail, 35.3 mm (23 - 42); hind foot, 8.2 mm (8 - 9); ear from notch, 13.2 mm (12 - 14); tragus, 6.4 mm (6 - 7); forearm, 37.2 mm (36 - 38). Weights of 13 adults collected during the winter months averaged 5.7 gms. Ten non - or very early pregnant females and five adult males killed during April, May, and June averaged 6.5 gms, the mean weight of the females (6.7 gms) slightly exceeding that of the males (6.0 gms). Postpartum females in June averaged heavier (7.4 gms) than any series of individuals collected at other times of the year.

Sixteen specimens were collected from caves in Hardin Co.—2¼ miles NW of Elizabethtown (1), 2½ miles N of Rosiclare (2), 4¼ miles NW of Rosiclare (4); and Union Co.—3 miles E of Cobden (9). Thirty-four were obtained from buildings or by shooting at Carbondale in Jackson Co.

Myotis austroriparius mumfordi Rice. Southeastern myotis.—Fourteen specimens were collected in three of the ten natural caves from which bats were obtained. None were taken in silica mines or prospect shafts. Two groups of southeastern myotis, with about 10 to 15 individuals in each, were found clinging to fairly smooth walls of a cave ½ mile NE of Rosiclare, Hardin Co., on December 21. This was probably the locality from which the species was first reported in Illinois (Smith and Parmalee, 1954). When this cave was revisited in March, a single male was seen. It became active as soon as a light was shown on it and flew deeper into the cave. About a half hour later it was captured back at the original site, a dry concavity in the wall of a side chamber. Single specimens were taken in caves 4¼ miles NW of Rosiclare on December 21 and 3 miles E of Cobden, Union Co., February 5. The latter individual was collected within a cluster of about ten *Myotis lucifugus* in a crevice in the ceiling of the cave. The temperature at the site was 47° F.

The uteri of all females collected were turgid, and, with a single exception, the right horn was markedly more distended than the left. A few sperm were observed in a smear of the contents of the right uterine tube and oviduct of one formalin-preserved female examined. All males secured had prominently enlarged cauda epididymides, containing copious amounts of sperm, and well-developed accessory sex glands.

Measurements of six males (forearm length available for only five) were: total length, 87.0 mm (82 - 92); tail, 40.3 mm (39 - 42); hind foot, 9.8 mm (9 - 10); ear from notch, 14.5 mm (14 - 15); tragus, 7.3 mm (6 - 8); forearm, 38.0 mm (37 - 39). Six females averaged as follows: total length, 89.8 mm (82 - 95); tail, 40.7 mm (38 - 42); hind foot, 9.3 (8 - 10); ear from notch, 14.7 mm (14 - 15); tragus, 7.7 mm (7 - 8); forearm, 38.8 mm (38 - 40). Mean weight of four males was 5.5 gms (4.5 - 7.7), and of six females, 5.9 gms (5.3 - 6.5).

Myotis keenii septentrionalis (Trouessart). Keen's myotis.—Hibernating individuals of this species were taken on two occasions. A male was collected from a narrow fissure in the ceiling at the rear of a natural cave 2¼ miles N of Rosiclare, Hardin Co., on December 21. The temperature at the site was 56° F. On February 12, two females were found crammed together at the end of a drill hole in the roof of a silica mine, 4 miles SW of Elco in Alexander Co. The hole, measuring about 10 inches in length and 1½ inches in diameter, was some 30 yards from the entrance to the mine. The light at this point was still rather bright. As the mine was only about 100 yards long, and the entrance approximately 8 to 10 feet wide, it is probable that interior temperatures fluctuated rather sharply with changes in the outside temperature. At the time of collection, the temperature of the hibernation site was 35° F., while that outside the cave was approximately 20° F. The bats became active immediately upon being touched.

The cauda epididymal tubules of the male contained sperm, and the accessory glands were enlarged. The uterus of the one female dissected was enlarged, and sperm were present in a smear of the horn and oviduct on the right side.

The measurements and weights of the male and two females, respectively, were: total length, 90, 87, 93 mm; tail, 41, 40, 38 mm; hind foot, 8, 8, 6 mm; ear from notch, 17, 16, 16 mm; tragus, 8, 9, 9 mm; forearm, 34, 36, 36 mm; weight, 6.1, —, 6.2 gms.

Myotis sodalis Miller and G. M. Allen. Indiana myotis.—Nine hibernating specimens were collected. Four males and four females were taken from two aggregations in crevices in the wall of a cave 4¼ miles NW of Rosiclare, Hardin Co., on December 21. These clusters were in the same position on March 12. On December 31 a lone female was secured in a cave in Union Co., 4 miles E of Cobden. The bat was clinging to the side of a narrow passage through which a stream flowed.

The cauda epididymis of all males collected contained sperm. Two of the females obtained December 21 were dissected and the uterine horns appeared to be turgid. The right uterine tube of the female collected December 31 was distinctly more swollen than the left.

Mean measurements and weights of three males and four females, respectively, and extremes for both sexes were: total length, 87.7, 90.0 mm (87 - 92); tail, 38.7, 40.0 mm (35 - 45); hind foot, 7.7, 7.5 mm (7 - 8); ear from notch, 13.7, 14.0 mm (13 - 15); tragus, 7.7, 7.2 mm (6 - 8); forearm, 38.7, 38.5 mm (37 - 41); and weight, 6.1, 6.8 gms (5.9-7.0).

Pipistrellus subflavus (F. Cuvier). Eastern pipistrel.—This species is one of the most common bats in southern Illinois. Hibernating specimens were collected or noted in all natural caves in which bats were found and occurred as the predominant species in nine of the eleven silica mines and prospect holes examined that contained bats. This was the only bat taken in the relatively short prospect holes. Air temperatures recorded in ten instances in parts of caves or mines where pipistrels were found varied from 41 to 58° F. Hibernating individuals occurred singly under light conditions ranging from twilight to total darkness.

On the basis of a limited sample, apparent sex ratios during the cold and warm parts of the year differed. Thirty-six hibernating specimens taken at random in mines and caves from November to March consisted of 29 males and 7 females, while 7 males and 15 females were shot in flight in May, June, August, and September. Seven specimens collected in caves in May, July, and August were all males. Ten fetuses in which sex could be determined included six males and four females.

Two males collected in July and three taken August 17 contained no sperm in the cauda epididymis. A specimen killed August 30 and all individuals collected during hibernation from December to

March were fertile. No sperm were noted in smears of the cauda epididymides of two males shot in May and June. Two females killed August 5 contained no sperm in the uterus. The genital tracts of all females examined during the winter months were turgid, and a smear of the upper portion of the uterine horns of one such female obtained December 21 contained sperm. No uterine swellings were visible in two females shot on May 12 and 21, although three others taken on the latter date were each carrying embryos ranging from 5 to 9 mm in crown-rump length. Of seven gravid females killed June 8, four contained nearly full-term fetuses and three had well-developed fetuses 12 to 15 mm in crown-rump length. The number of young was two in each case. As evidenced by this sample, the peak of parturition in southern Illinois apparently occurs in June.

Mean measurements of 15 males and 10 females, respectively, and the extremes for both sexes combined were: total length, 82.0, 83.7 mm (77 - 89); tail, 36.6, 37.6 mm (30 - 40); hind foot, 7.9, 7.3 mm (6 - 8); ear from notch, 13.1, 13.1 mm (12 - 14); tragus, 6.1, 6.1 mm (6 - 7); forearm, 32.9, 33.7 mm (31 - 36). The average weight of 30 hibernating individuals collected between November and March was 4.8 gms (4.0 - 6.4). The average of 17 specimens shot during the evening flight from May to September was 5.2 gms (4.1 - 7.5).

Forty-nine specimens were collected from the following localities: Alexander Co.—2½ miles NW of Elco (11), 4 miles WSW of Elco (1); Hardin Co.—2¼ miles NW of Elizabethtown (3), ½ mile NE of Rosiclare (2), 2¼ miles N of Rosiclare (3), 4¼ miles NW of Rosiclare (3); Jackson Co.—Carbondale (2), Pomona (3); Johnson Co.—2½ miles SW of Cypress (2); Pope Co.—1 mile SE of McCormick (4); Union Co.—2½ miles E of Cobden (4), 3 miles SW of Cobden (5), 2 miles W of Mill Creek (2), 3 miles W of Mill Creek (2), 3 miles E of Mill Creek (2).

Lasionycteris noctivagans (Le Conte). Silver-haired bat.—Four specimens were found hibernating in old silica mines in Alexander County on February 12. A single male was taken from a vertical fissure about 8 feet above the floor in a large room at the rear of a mine 2½ miles WNW of Elco. The room was totally dark and had a temperature of 31° F. A male and two females were collected from a small mine in a well-wooded hillside overlooking a stream and cultivated fields 4 miles SW of Elco. The mine was a straight shaft about 100 yards long and 8 to 10 feet in diameter. The three bats were wedged into a horizontal crack near the roof approximately 40 yards from the entrance. The hibernaculum was in fairly strong light and the temperature, taken within a few inches of the crack occupied by the bats, was 35° F.

The bats were not in deep torpor at either collecting site. They emitted a sharp, rasping, buzzy cry and moved stiffly as soon as touched. They also uttered a high-pitched, bird-like peeping note after becoming slightly more active.

The cauda epididymis of one male dissected was not greatly enlarged and relatively few sperm were present in a smear of the

tubules. The genital tracts of both females were swollen and vascular. Sperm were visible in smears of the oviducts of both individuals.

Measurements in millimeters and weights in grams of the four individuals (females in parentheses) were: total length, 98, 102 (101, 107); tail, 41, 41, (39, 44); hind foot, 8, 8 (6, 8); ear from notch, 14, 16 (16, 14); tragus, 6, 7 (6, 6); and weights, 7.8, 9.0 (10.6, 11.4). Fat deposits were conspicuously heavier in the females than in the males.

Eptesicus fuscus fuscus (Palisot de Beauvois). Big brown bat.—Hibernating *Eptesicus* were collected or noted in four of ten natural caves visited and in three of eleven silica mines or prospect holes that were examined for bats. Torpid specimens were generally encountered singly, although in one instance two bats were found lying one on top of the other in a small horizontal crevice. The uppermost was on its back. Except for one other case in which a single individual was discovered resting on a small ledge of rock, all other bats of this species that were seen were hanging on exposed walls or wedged into vertical cracks in walls or ceilings of caves or mines. In general, big brown bats appeared to select hibernation sites nearer to the entrances of caves or mines, often in fairly strong light, than did other bats which were present. Temperatures recorded on three occasions at the point where big brown bats were hibernating were 31, 35, and 46° F.

In the period from April to August, specimens were collected from a summer colony in the attic of the same building on the Southern Illinois University campus that was occupied by *Myotis lucifugus*. They were also shot in the evening at a point about one-eighth of a mile from the colony. In all probability the bats killed at the latter station belonged to the colony. *Eptesicus* was not taken at any of four other stations at which bats were shot during the summer.

Females predominated in the total number of specimens taken (13 males, 44 females). Of 13 hibernating individuals, three were males and ten, females. In April, three males and two females were collected during the evening flight, while a single male was killed in May, as compared to 13 females. In June, following the period of parturition, males appeared to become more abundant, the number of big brown bats shot in that month consisting of six males and 13 females. These limited data may indicate that the sexes not only segregate during the period of birth but may also either tend to utilize somewhat mutually exclusive hunting territories or to occupy separate roosting sites some distance apart. Six *Eptesicus* collected from the attic colony in August were females. Four fetuses whose sex could be positively determined were all males.

Three hibernating males collected in the interval from December 31 to February 12 had small testes but contrastingly enlarged epididymides. No sperm were visible in smears of the cauda epididymis of nine individuals examined between late April and the end of June. Six females autopsied between August 9 and 21 had apparently not yet mated, since no sperm could be detected in smears of the uteri.

Females taken during hibernation from December to March had sperm in the uterine tubes. A very early pregnancy was recorded April 12, while two females carrying near-term fetuses, two in each case, were shot May 22 and 23. Eleven others obtained between May 22 and 31 were in post parturient condition. The uteri of five specimens were still much enlarged, indicating recent partum, while those of the others were noticeably reduced in size from the condition existing shortly after birth. Only one of 12 females collected in June gave evidence of recent parturition. The tubal genitalia of the rest had regressed to the anestrous condition or were only slightly enlarged. The period of birth in *Eptesicus* in southern Illinois thus appears to occur largely in May. This corresponds rather closely with the findings of Christian (1953) in a study of a summer colony of big brown bats in Maryland.

Average measurements of five males and ten females, respectively, followed by the extremes for both sexes combined are: total length, 110.8, 120.6 mm (105 - 126); tail, 44.4, 46.0 mm (42 - 52); hind foot, 9.0, 10.3 mm (8 - 12); ear from notch, 16.8, 17.6 mm (16 - 18); tragus, 8.0 8.2 mm (7 - 9); forearm, 47.2, 47.3 mm (45 - 50). Weights of ten hibernating individuals averaged 18.1 gms (13.7 - 23.0), while those of 33 specimens killed during the evening flight from April to June averaged 17.2 gms (11.4 - 22.6).

Fifty-seven specimens were collected from the following localities: Alexander Co.—1½ miles NW of Elco (4), 2½ miles WNW of Elco (2), 1 mile NE of Olive Branch (1); Hardin Co.—½ mile NE of Rosiclare (2), 2¼ miles N of Rosiclare (3); Jackson Co.—Carbondale (44); Union Co.—3 miles E of Cobden (1).

Lasiurus borealis borealis (Müller.) Red bat.—This species appeared to be the most common bat in southern Illinois during the warmer months. In 1954, the last date in fall on which red bats were recorded was November 14. The first spring record was a specimen collected on March 12.

At stations where bats were shot, red bats were almost invariably the first to appear after sunset. When first observed they were often flying at some height, but as the light faded they dropped to lower elevations. The greatest numbers were seen shortly after the first active individuals were noted, but there are probably more irregular feeding periods throughout the night, as evidenced by individuals seen flying about street lights or floodlit parking areas at all hours during the night. Red bats seen under the latter circumstances gave the impression of flying more swiftly and directly than during the early evening flight. A red bat was seen flying by Earl Stadelbacher and Kenneth Hill about 3 p.m. on August 24.

The balance of the sexes in the total number of red bats collected was greatly in favor of the females (12 males, 35 females). This disparity may at least in part be due to differential behavior of the sexes, particularly during the period of parturition. In March and April, two males and three females were collected, whereas in May,

the main period of birth, only one male was taken as compared to nine females. In June, after the birth of the young, the proportion of the males taken (5 males, 19 females) seemed to be increasing. There was an equal number of both sexes in eight adults collected in August. Although the data are few, an equal number of males and females in ten near term fetuses or recently-born young suggests a 50 - 50 primary sex ratio.

Four males collected in August had well-developed accessories and enlarged epididymides containing sperm. A specimen examined March 21 and another on May 12 still contained sperm in the cauda epididymis, but no sperm were visible in smears of the epididymis of four males killed during June. Mating apparently occurs sometime after August, as four females killed from August 4 to 28 showed no sperm in smears of the vagina and uterine tubes. A female with embryos measuring 2.5 mm in crown-rump length was killed April 28, providing the earliest record of pregnancy. Specimens collected April 29 and 30 had enlarged uteri with no discernible swellings and slight uterine swellings containing tiny embryos, respectively. Three females killed during the first week of May contained embryos measuring 5 mm. One examined during the second week had 8 mm embryos, and the embryos of three bats taken in the third week measured 7, 11, and 12 mm. During the last week of May two females carrying well-developed fetuses 13 and 17 mm in crown-rump length were killed. The greatly enlarged and flaccid uterine horns of the five specimens taken during the first week in June signified recent parturition. Of four examined the second week, one female had recently given birth while the reproductive tracts of the others showed some reduction from the size at partum. The tubal genitalia of ten specimens obtained during the last half of June had returned to the anestrous condition. It thus appears that the majority of red bats in southern Illinois give birth to their litters during the latter part of May and early June.

Red bats seemed to become scarce in the interval from May 15 to 28. The number of bats seen and shot then increased in June, when only females that had already borne their young were collected. These data suggest that females in an advanced stage of pregnancy may be less active or more circumscribed in their evening feeding flights. No females were carrying young when shot. In view of the number of red bats killed shortly after parturition and during lactation, it would be assumed that some females carrying young would have been taken if this is a normal habit of the species. It seems likely that red bats do not under ordinary circumstances carry even small young in flight.

Of the gravid females collected, six contained three embryos and five, four embryos.

On June 13 Dyke Howell discovered a female with three nursing young clinging to the side of a house about 3 feet above the ground, in bright sunlight. The young weighed 3 gms each and were well furred. The eyes were still closed. The family was kept indoors for

several days. The mother readily hung onto a clothespin attached to a house plant and fed upon small pieces of beef, which were chewed thoroughly. In the evening the mother often changed her position or left the plant entirely. At such times the young would remain clinging to the clothespin. When the mother was replaced they would clamber onto her and locate the nipples. The adult was extremely vicious, clicking and buzzing whenever approached and actually leaping several inches off the floor in an attempt to bite a hand extended toward her. When hanging from a perch, she would snap her wings when annoyed.

Average measurements of nine males and 26 females, with extremes for both sexes combined were: total length, 101.1, 109.5 mm (95 - 115); tail, 44.7, 48.1 mm (35 - 54); hind foot, 6.8, 7.0 mm (6 - 8); forearm, 40.6, 40.0 mm (35 - 48). Weights of nine males and 19 non-gravid females averaged 9.6 gms (8.0 - 10.8) and 12.3 gms (7.7 - 16.0), respectively. Some individuals taken in August had put on as much as 2.6 gms of subcutaneous fat, whereas others showed little fat deposition. It is possible that the latter were young of the year and that they do not attain their fat stores as early as the adults. If this is the case, it would be of interest to learn how the rate of fat storage in young and adults correlates with the time of departure on the fall migration.

Forty-seven specimens were collected at the following localities: Jackson Co.—Carbondale (28), DeSoto (2), Pomona (2); Perry Co.—Pyatt (4); Union Co.—2½ miles NE of Aldridge (5), 3 miles SW of Cobden (5); Williamson Co.—4 miles E of Carbondale (1).

Lasiurus cinereus cinereus (Palisot de Beauvois). Hoary bat.—No specimens were collected, although single large bats that were almost assuredly of this species were observed at the edge of the Southern Illinois University campus on April 22, 29, and 30. A hoary bat with a broken wing was collected in the middle of a street in Carbondale after a heavy rainstorm in the summer of 1952 by Dyke Howell. The skin of this specimen is in the collection of the Department of Zoology, Southern Illinois University.

Nycticeius humeralis humeralis (Rafinesque). Twilight bat.—Eleven individuals were shot during the period from April 13 to June 20 at Carbondale. All specimens were killed while flying at the periphery of, or within, clearings in a tract of mature woodland at the edge of the Southern Illinois University campus. Together with the red bat, they were the earliest bats to appear in the evening, often beginning to fly in clearings within the woods while the light was still quite strong. Two individuals observed under the latter conditions flew at tree-top height, following the same circular or oval course of approximately 100 to 200 feet in diameter for several minutes at a time. The main course was frequently interrupted by short side darts accompanied by quicker wing beats.

Of the 11 *Nycticeius* killed, only two were females. Males were

apparently sexually inactive by the end of April. Although sperm were fairly abundant in the epididymis of a specimen shot April 22, they were infrequent in epididymal smears of four individuals examined from May 4 to 29. Sperm were not present in smears of the cauda epididymis of three males shot May 26 and 27. A female killed April 22 had much-enlarged uterine tubes probably indicative of early pregnancy, although definite uterine swellings were not discernible. A lactating female whose greatly enlarged and flaccid reproductive tract evidenced recent parturition was taken June 20.

Average and extreme measurements of the 11 specimens were: total length, 88.6 mm (81 - 95); tail, 35.6 mm (31 - 40); hind foot, 6.9 mm (6 - 8); ear from notch (6 specimens only), 11.8 mm (9 - 14); tragus (6 specimens only), 5.7 mm (4 - 6); forearm (10 specimens only), 35.7 mm (33 - 39). Weights ranged from 6.5 to 11.1 gms, averaging 8.0 gms.

Corynorhinus rafinesquii (Lesson). Big-eared bat. — Handley (1955) has pointed out that the name *C. rafinesquii* (Lesson) is properly applicable to the species formerly known as *C. macrotis* (Le Conte). Two hibernating males of this species were collected January 30 in abandoned silica mines located 3 miles WSW and 4 miles NW of Mill Creek in Union Co. Both mines were situated in mature oak, hickory, and beech woodlands. In each case the bat was found at the rear of the mine in total darkness. Both individuals were hanging about 10 feet above the floor. The ears were characteristically curled and the forearms were held with the elbows slightly spread, giving the animal a somewhat triangular appearance when viewed from a distance. The bats were in deep torpor and did not begin to show any signs of activity until 5 or 10 minutes after collection. Temperatures recorded at the sites occupied by the individuals were 52 and 58° F.

The testes of both specimens were 6 mm in length and 4 mm in width. The epididymides were greatly enlarged and contained quantities of sperm.

Measurements were: total length, 100, 103 mm; tail, 45, 50 mm; hind foot, 11, 10 mm; ear from notch, 34, 32 mm; tragus, 12 (dried), 13 mm; forearm, 42, 44 mm. The weights were 8.7 and 9.5 gms.

Sylvilagus floridanus (J. A. Allen). Cottontail.—Cottontails were collected or seen in both swampy and dry woodlands, hedgerows, brushy and fallow fields, overgrown strip-mined lands, and on lawns in towns. They were noted along country roads at night in considerable numbers during March and April, and it is possible that this was a reflection of increased activity associated with the breeding season. On one occasion a running adult cottontail was timed by a car over a short distance at 18 m.p.h.

Reingested fecal pellets were noted in the stomach of a cottontail collected at 2:30 p.m. on February 12, but no such pellets were found in the stomachs of two individuals collected April 1 at 10:30 p.m.

A male collected November 6 was not in breeding condition. In-

dividuals shot from February 12 to April 1 had greatly enlarged testes and abundant sperm in the epididymis. No visible embryos were noted in two females collected February 12 and 19, whereas a specimen killed March 15 was carrying four large fetuses. Another taken April 1 contained five 15 mm embryos. A nest of five young was reported by Earl Stadelbacher on March 28, and a small individual, apparently just out of the nest, was noted April 17. Young rabbits about a third grown were observed in July.

Average external measurements taken of 11 adults by Fred B. White were: total length, 444.0 mm; tail, 53.2 mm; hind foot, 96.9 mm; ear from notch, 60.7 mm. Means of the skull measurements of these specimens were: basilar length, 58.4 mm; length of nasals, 33.0 mm; breadth of rostrum above premolars, 20.5 mm; depth of rostrum in front of premolars, 15.9 mm; interorbital breadth, 18.6 mm; parietal breadth, 25.3 mm; diameter of bullae, 10.9 mm. Weights of nine specimens ranged from 2 lbs. 8 oz. to 4 lbs., with a mean of 3 lbs.

The subspecific status of the cottontail in southern Illinois is not clear. Nelson (1909), Necker and Hatfield (1941), Hall (1951), and Hoffmeister and Mohr (1957) have referred cottontails in the extreme southern portion of the state to *alacer,* while Cory (1912) considered *mearnsii* as occurring throughout the state. In actuality, a thorough study may reveal the presence of intergradation between three forms, *mearnsii, alacer,* and *mallurus,* in southern Illinois. On the basis of mean external and skull measurements given by Nelson (1909) for the various subspecies of *Sylvilagus floridanus,* 11 specimens from southern Illinois approach *mallurus* and *mearnsii* in total length, have a smaller tail length than any of the three, and are closer to *mallurus* in hind foot and ear length. They are nearer to *mallurus* and *mearnsii* in six of seven skull measurements recorded, agreeing most closely with *mallurus* in four of these. They approach *alacer* in parietal breadth only.

Cottontails were collected at the following localities: Alexander Co.—Cache (3); Jackson Co.—4 miles NW of Carbondale (2), 10 miles S of Carbondale (2); Pomona (1); Johnson Co.—13 miles E of Cobden (2). Individuals were seen at the following places: Alexander Co.—¾ miles NNW of Olive Branch; Hardin Co.—13 miles NE of Golconda; Union Co.—Aldridge. Specimens were also examined from Pyatt, in Perry Co.

Sylvilagus aquaticus aquaticus (Bachman). Swamp rabbit.—Although the range of the swamp rabbit in Illinois extends north at least to Salem, it appears to be most abundant in the lowlands of the Coastal Plain Province at the southern extremity of the state. Specimens were collected in such open situations as wet swales and dry, brushy fields in close proximity to swamps or wooded stream banks, and in typical bottom woodlands of oaks, hickories, red maple, sweet gum, elm, ash, and sycamore. Groups of large fecal pellets, frequently deposited on logs or stumps, were a characteristic sign of the presence of this species. In swampy woodlands, droppings appeared to be more abundant in the drier parts, and in one case there was less evidence

of this sign in a tract of flooded woods in late winter and early spring than there had been in the fall when the woods were much drier. It thus seemed that the rabbits tended to avoid extensively inundated areas by shifting their activity to drier lands, although they readily take to water when the situation demands. In no case, however, were swamp rabbits or their sign noted at any great distance from swampy woodlands. Observations made while collecting these rabbits on February 20 near Cache suggest that temperature may also play a role in their selection of habitat. On this date, temperatures were unusually low for the region, ranging from about 5° F. in the early morning to 20° F. later in the day. Most of the swamp rabbits observed were flushed from sunny, dry, brushy situations and outnumbered cottontails which usually predominated in such cover at this locality.

In open areas swamp rabbits probably spend the day in forms. Two of these examined shortly after the animals had been flushed were located in dense clumps of vegetation and were noticeably damp to the touch. The rabbits also rest in exposed positions on the ground in woodlands, and hunters claim that they will take refuge in hollow stumps or logs. A specimen collected in bottomland woods on January 1 was flushed from a burrow located beneath the roots of a tree at the top of a steep, muddy, creek bank.

Because of the difficulties of hunting them, even with good hounds, and the rather restricted area covered by their habitat, swamp rabbits are apparently not taken by southern Illinois hunters in any numbers. Perhaps not over 200 are ordinarily killed during the course of a season. In periods of high water, however, they may become more vulnerable. One instance was reported to me of a hunter who killed "about 140 pounds" (25 to 30 individuals) of swamp rabbits from a boat drifting downstream on the Big Muddy River during a period of high water in December of one year. Floods may in themselves cause a high mortality in the species, as many persons living in swamp rabbit country believe that the numbers of rabbits decline markedly after hc y floods. Herbert Dare, Jr., told of seeing swamp rabbits drifting down the flood-swollen Big Muddy River near Mount Vernon on logs and floating debris. Swamp rabbits are also accidentally trapped in muskrat sets on occasion.

A young male taken January 1 was still partially clothed in the dull, fuzzy juvenile pelage. It weighed only 2 lbs. 2 oz. and had not yet attained puberty. Six males examined between January 2 and April 9 were fertile. Their gonads averaged 27.2 × 13.0 mm in length and width, respectively. It is of interest to note that, despite the greater size of the swamp rabbit, the testes of sexually active males are much smaller than those of the cottontail at a similar stage of the sexual cycle. Faint placental scars in the uteri of three females killed during January numbered 3, 3, and 4. A gravid specimen collected April 9 contained four nearly full-term fetuses.

The habit of coprophagy or reingestion in North American lago-

morphs has been recorded in *Sylvilagus palustris* (Hamilton, 1955), *S. floridanus*, (Kirkpatrick, 1956; Geis, 1957), and *Lepus californicus* (Lechleitner, 1957). This habit is also exhibited by the swamp rabbit. Reingested pellets were recorded in all of 15 stomachs examined. These amorphous objects varying from about 6 to 10 mm in greatest dimension, were soft and putty-like in consistency and yellowish-brown to light greenish-gray in color. They invariably occurred in the cardiac portion of the stomach and were generally embedded in a matrix of ingesta. The latter, in the anterior part of the stomach, was ordinarily neither as coarse in texture nor as dark green in color as that in the pyloric region. The numbers of pellets found in individual stomachs ranged from 4 to over 200, and in nine cases were estimated to comprise from 50 to 70 percent of the total stomach contents. The specimens whose stomachs were examined were collected between 9 a.m. and 5 p.m. No correlation between the number of pellets and time of collection was apparent.

Average measurements of six males and nine females, respectively, and extremes for both sexes combined were: total length, 519.0, 529.1 mm (498 - 559); tail, 59.5, 63.0 mm (42 - 82); hind foot, 109.7, 109.4 mm (105 - 114); ear from notch, 71.0, 69.8 mm (64 - 78). Weights of the adults, excluding one female in advanced pregnancy, ranged from 4 lbs. 13 oz. to 5 lbs. 7 oz. According to hunters familiar with the swamp rabbit, considerably greater weights may be attained.

Sixteen specimens (7 males, 9 females) were collected at the following localities: Alexander Co.—Cache (6), 2 miles NW of Cache (4), 4 miles SW of Olive Branch (2); Jackson Co.—12 miles N of Murphysboro (1); Marion Co.—10 miles E of Salem (1); Union Co.—2 miles S of Ware (2). Additional records contributed by individuals considered to be reliable observers include: Jackson Co.—5 miles NW and 4 miles N of Carbondale; Jefferson Co.—7 miles SW of Mt. Vernon; Massac Co.—Metropolis; Perry Co.—Duquoin; Randolph Co.—Sparta.

Marmota monax monax (Linnaeus). Woodchuck.—Of the areas visited during the course of field work, woodchucks were particularly abundant in strip-mined lands at Pyatt in Perry County and along the wooded bluffs in the area known locally as the Pine Hills east of Aldridge in Union County. In early April, individuals were often seen basking in the sun at the entrance to their burrows in the railroad embankment along State Highway 127 in Jackson County.

Two males collected October 8, 4 miles N of Mt. Vernon in Jefferson County, and November 23, 2 miles E of Cobden in Union County, were extremely fat, weighing 10 lbs. 2 oz. and 9 lbs. 9 oz., respectively. An emaciated yearling, captured on an island in Crab Orchard Lake in Williamson County during April, weighed only 3 lbs. 8 oz.

Tamias striatus (Linnaeus). Eastern chipmunk. — This species, occurring in rather localized populations in southern Illinois, shows a definite predilection for mature woodlands with rocky outcrops and

an abundance of old logs and stumps. Chipmunks were encountered in greatest abundance in a beech-maple forest fringing the bluffs bordering the Big Muddy River bottomlands southeast of Murphysboro. They appeared to be entirely restricted to the narrow band of beech and maples on the slope between the bluffs and the typical bottomland woods beyond.

Specimens were collected or observed from May 1 to November 14. Although considerable time was spent in good chipmunk habitat subsequent to the latter date, no activity was noted during the winter months. As has been the experience of other workers, a great flurry of chipmunk activity was noted in the fall months. The soft, mellow, "chuck" note, which seems to be more commonly given in autumn than at other seasons, was heard for the first time in fall on September 25, although chipmunks had been active in the woods since early in the month.

A full-grown spring-litter male collected July 25 and a partly-grown summer-litter male obtained November 1 showed no sign of sexual activity. The testes of all adult males taken from September through November were small and sperm were lacking in the cauda epididymis. Three adult females examined in September were no longer lactating, although the mammae were still moderately enlarged. Each contained five placental scars in the uteri. Seven placental scars were visible in a lactating individual trapped May 2. A juvenile male weighing 58.0 gms and estimated as being slightly over a month in age was killed May 1. The summer-litter juvenile obtained in November weighed 88.4 gms and was probably about two months old. These data indicate that the period of reproduction in chipmunks in southern Illinois extends at least from March to August.

In addition to mast and other plant materials, the stomachs of three individuals contained abundant insect remains. Cheek pouches of three animals yielded two snails (*Haplotrema concavum* and *Stenotrema fraternum*), a slug, and several seeds.

Average measurements and weights of two adult males and five adult females were: total length, 258.6 mm (246 - 270); tail, 92.3 mm (85 - 97); hind foot, 36.0 mm (34 - 38); ear from notch, 18.7 mm (18 - 22); weight, 115.9 mm (108.1 - 121.5).

Specimens of *Tamias* from southern Illinois are noticeably darker than examples of *T. s. griseus* from the northern part of the state. Cory (1912) indicates *T. s. striatus* to be the subspecies occurring in southern Illinois. Wetzel (1947) suggested the possibility that a specimen from Murphysboro, Jackson County, is referable to *T. s. ohionensis*. Goodpaster and Hoffmeister (1952) have recorded the latter from northwestern Tennessee, and Hoffmeister and Mohr (1957) believe it to be present in the Wabash and Ohio river valleys in Illinois, *Tamias s. griseus* occurring throughout the remainder of the state. Further study of a satisfactory series of specimens together with a critical revaluation of the validity of the subspecies *T. s. ohionensis*

appears necessary to satisfactorily establish the taxonomic status of the chipmunk in southern Illinois.

Thirteen specimens (6 males, 7 females) were collected in Jackson and Union Counties from the following localities: 3 miles N of Carbondale (1), 3 miles E of Carbondale (1), 7 miles SW of Murphysboro (4), Pomona (3), 1 mile E of Aldridge (2), 1½ miles N of Cobden (1), and Wolf Lake (1). B. J. Verts collected a small series at Pyatt in Perry County in the fall of 1954. Ronald Yates reported shooting a specimen in June, 1954, in Johnson County along the bluffs bordering railroad tracks about 3 miles N of Belknap. Chipmunks were said to be fairly common at this locality.

Sciurus carolinensis carolinensis Gmelin. Gray squirrel. — Gray squirrels were most in evidence in extensively forested uplands of oak, hickory, beech, and maple and less frequent in typical bottomland woods.

Mean measurements and weight of three adults were: total length, 466.3 mm; tail, 206.7 mm; hind foot, 66.0 mm; weight, 499.6 gms.

Five specimens were collected at the following localities in Jackson Co.: 3 miles NE of Carbondale (1), Pomona (4).

Sciurus niger rufiventer È. Geoffroy-Saint-Hilaire. Fox squirrel. — In southern Illinois these squirrels characteristically inhabit bottomland forests and more or less isolated woodlots and fence rows. They were particularly abundant in the town of Carbondale, where a number of incidental observations on molt and behavior were made.

In July, specimens that were apparently spring juveniles were molting. The old coat appeared fuzzy and grayish, whereas the new pelage was sleeker and more olivaceous, resembling the summer pelage of the adult. The direction of the change was from the head toward the tail. In one individual with new fur back to about midbody, patches of fresh pelage were also visible on the anterior edge of the hind limbs from the knee to the body. Full-grown squirrels were beginning to molt the tail in August, and in September an individual was seen that had new fur on the tail and body to about its middle. Five adults noted from November 18 through March 17 were in full winter pelage and showed no evidence of molt. On March 18 an individual was observed in which replacement of hair on the head, shoulders, and upper arms was in progress. A molting squirrel was recorded March 24 and one seen April 5 had a patch of summer fur between the shoulders. Molt had just begun on the head and shoulders of a specimen seen April 14. A squirrel noted April 29 had molted the entire body anterior to the hind legs. Baumgartner (1943) has reported only one annual molt in the fox squirrel, but these observations seem to indicate the occurrence of two body molts in adults. The spring molt progresses from the head rearward and the fall molt in the reverse direction. The tail hairs appear to be replaced only in the fall, prior to the initiation of the body molt. Spring juveniles apparently undergo a molt in summer which follows the pattern of the adult spring molt.

On January 28 an adult fox squirrel was observed licking sap oozing from a broken limb of a sugar maple. There were numerous scars where the animal had nibbled on the parts of the branch and trunk that had been moistened with sap. Two individuals were noted feeding on the flower buds of red maple on February 23. An interesting example of interspecific strife between a fox squirrel and starlings was observed on one occasion. The squirrel was foraging in a freshly-plowed garden plot where starlings were also present. Several times the squirrel was seen to rush and drive off starlings that approached to within 5 or 6 feet of it.

An adult female collected in early October was lactating, while another taken in November was not. The placental scars in these two specimens numbered five and six, respectively. Abundant sperm were contained in the cauda epididymis of a male killed December 4, whereas another, a summer juvenile by its appearance, was not in breeding condition when collected December 21.

Average measurements and weight of four adults were: total length, 524.0 mm; tail, 240.0 mm; hind foot, 70.0 mm; weight, 750.3 gms.

Five specimens were collected at the following localities: Jackson Co.—Carbondale (2); Pulaski Co.—Wetaug (1); Randolph Co.—5 miles W of Sparta (1); Union Co.—4 miles SW of Cobden (1).

Glaucomys volans volans (Linnaeus). Eastern flying squirrel. — Flying squirrels probably occur generally in wooded areas throughout southern Illinois. Specimens were collected in upland areas forested with oaks, hickory, beech, and hard maple; in isolated oak-hickory woodlots; and in typical swampy woodlands of black oak, sweet gum, and red maple.

In a tract of predominantly oak-hickory woodlands near Pomona which was visited fairly regularly throughout the year, flying squirrels were most in evidence during the fall months when engaged in feeding on nuts. The soft, chippering notes of the animals were heard before darkness, but the most intensive activity, as judged by the calls and shower of falling nuts and hulls, occurred from just after sunset to about 9 p.m. During visits in September and October the impression was gained that the animals were working almost exclusively in the trees, but in November when most of the mast crop had been cut or had fallen the flying squirrels were heard foraging on the ground more frequently.

An adult female and two young were collected on September 4 from a leaf nest in an elm growing beside a steep limestone bluff. The nest measured about 10 inches in diameter and was composed of a loose outer sheaf of leaves and an inner sphere of shredded inner bark about 5 or 6 inches in diameter. It was situated in a dense tangle of grape vines at a height of about 20 feet. A male collected October 30 was not fertile, and a nulliparous female taken October 31 showed no sign of reproductive activity.

Measurements and weights of the adult female and male were: total length, 227, 217 mm; tail, 92, 96 mm; hind foot, 32, 28 mm; weight, 69.5, 59.7 gms.

Single specimens were collected at each of the following localities: Alexander Co.—1½ miles NW of Cache, 2¾ miles NNW of Olive Branch; Jackson Co.—Carbondale, Pomona, 5¼ miles NW of Pomona.

Castor canadensis Kuhl. Beaver. — Signs of beaver were encountered in several localities in Union County. Old cuttings and canals were noted at a pond formed by the mining of kaolin 3 miles SW of Cobden; fresh tracks were seen along drainage ditches in the Union County Game Refuge 5 miles SE of Ware. Evidence of several former and recent beaver colonies was observed in the swampy woodlands bordering the limestone bluffs between Aldridge and Wolf Lake in the area known locally as the Pine Hills. The most active of these sites was a pond located alongside a road paralleling the bluffs. The beaver had dammed a spring run which issued from beneath the bluff and passed under the road. The dam was roughly semicircular and tied into the road bank at either end, enclosing a pond about 50 yards by 100 yards in greatest dimensions. A large lodge was located toward the center of the pond. During the summer months the pond and dam were overgrown with vegetation and little sign of beaver activity was apparent. Extensive cutting of saplings and other woody growth was noted in the vicinity of this site in October, and fresh mud and tracks along the dam were indicative of the fact that it was being repaired and added to. Fresh cuttings were also recorded on various dates in December and January.

Peromyscus maniculatus bairdii (Hoy and Kennicott). Prairie deer mouse. — Four specimens were trapped in brushy or weedy fields in April and October. A fifth was captured by hand beneath a heap of vines in a cutover soybean field in December. House mice were found under other such piles, which were scattered over the field, and represented the only cover present.

All of the mice were males in breeding condition. Measurements of five and weights of four were: total length, 136.2 mm (120 - 147); tail, 54.8 mm (49 - 59); hind foot, 17.6 mm (16 - 19); weight, 15.4 gms (13.0 - 17.8).

Specimens were obtained at the following localities: Alexander Co.—2 miles NE of Olive Branch (1); Jackson Co.—Carbondale (1); Massac Co.—Metropolis (1); Union Co.—4 miles NW of Cobden (2).

Peromyscus leucopus (Rafinesque). White-footed mouse. — This species is perhaps the most ubiquitous mammal in southern Illinois. Habitat types in which white-footed mice were recorded were trapped for a total of 3,160 trap nights. The species appeared to be most abundant in typical bottom woodlands, where a total of 75 individuals were collected in 1,136 trap nights. Most of the sites trapped were, at least occasionally, partly or completely flooded during the year. In several cases, mice were seemingly abundant in swampy woodlands

with considerable areas of standing water and evidence of recent total inundation. Two extensively wooded tracts of typical oak, hickory, sugar maple, and beech upland forests were trapped and only four *P. leucopus* were taken in 300 trap nights. Seven specimens were collected on ledges and crevices in limestone bluffs bordered by woodlands during 176 trap nights. The mice occupied the same sort of situations as did woodrats and were probably nesting in crevices in the bluffs. Fifty-seven trap nights in low, dense, brushy woods with thick grape vine tangles and abundant ground cover yielded four specimens. Five mice were collected in 790 trap nights in brushy fields, and six were obtained in 138 trap nights in open grassy fields. Ninety-seven trap nights in an overgrown roadside ditch, brush piles bordering a swale, and in a grass and brush border of a swamp produced three animals. Five specimens were caught in a cattail marsh some 50 yards from the nearest woodland cover in 498 trap nights. Droppings and food remains of *Peromyscus* were found several times in natural limestone caves examined for bats. On one occasion an individual was observed deep within such a cave.

Of four adult males examined in July, three were in nonbreeding condition. With a single exception, all of 46 adult males autopsied from August through the following June were fertile. Four adult females collected in July were reproductively inactive. Lactating or gravid females were trapped in October, January, April, and May. These data suggest that there may be a period of reduced or discontinued reproductive activity in both sexes during the hotter months of the year in southern Illinois and that breeding occurs throughout the winter months. The mean number of placental scars in 24 females was 4.3 (1 - 7). Nine pregnant animals contained an average of 3.8 (2 - 6) embryos or fetuses. Two instances of resorption, involving a single fetus in each case, were noted.

White-footed mice collected in late summer and early fall showed a rather high incidence of parasitism by the botfly (*Cuterebra*). Seventeen specimens out of 58 trapped in July, August, and October contained botfly larvae or bore characteristic scars as evidence of previous infestation. Evidence of the occurrence of botfly parasitism outside of these three months was not obtained, although it is true that the months of September, November, and March are not represented in this material and few specimens were examined in some of the others. Only single larvae were recorded. Of those mice bearing scars, three of the ten had two, while the remainder had single ones. In one individual the bot occurred in the lumbar region, but in all others the larvae or scars were located in the inguinal region.

Mean and extreme measurements of 78 adults (44 males, 34 females) were: total length, 168.1 mm (143 - 185); tail, 75.1 mm (62 - 85); hind foot, 20.1 mm (18 - 22); weight, 22.1 gms (16.4 - 29.4).

Intergradation between *P. l. leucopus* and *P. l. noveboracensis*

appears to occur through Illinois and the status of populations in the southern part of the state is not certain. However, specimens from this region are probably most nearly referable to the nominate subspecies, principally on the basis of smaller average size than typical *noveboracensis*.

Specimens were collected at the following localities: Alexander Co.—1½ miles NW of Cache (23), 2½ miles SE of Cairo (5), ½ mile NNW of Olive Branch (7), 3 miles NNW of Olive Branch (1), Tamms (3), ½ mile W of Tamms (15); Jackson Co.—Carbondale (3), Giant City State Park (2), 3 miles N of Pomona (2), 5 miles WSW of Pomona (2), 7 miles SW of Murphysboro (1); Massac Co.—1½ miles N of Metropolis (5); Perry Co. —Pyatt (1); Pope Co.—½ mile E of McCormick (1); Union Co.— Aldridge (8), 1¾ miles E of Aldridge (8), 6 miles WNW of Alto Pass (1), 3 miles N of Cobden (14), 4 miles N of Cobden (3), Union County State Forest (1), 2½ miles SW of Ware (19), Wolf Lake (11).

Peromyscus nuttalli aureolus (Audubon and Bachman). Golden mouse. — One specimen was trapped in a sumac thicket, with ground cover of brome sedge, a short distance from open woods with dense grape vine tangles. Four others were caught in or near canebrakes, or brushy situations, in moist woodlands with such trees as sweet gum, elm, tulip poplar, white oak, shagbark hickory, and sassafras predominating.

Two individuals were flushed from a nest in a small tree in December. The nest was placed about 10 feet high in a grape vine tangle. It measured about 7 inches in outside diameter and was composed of a grape bark outer shell, incomplete on top, and an inner sphere of softer vegetable fibers. The lining of the nest chamber contained some downy plant material and a few feathers. Many seeds of *Polygonum*, a few droppings, and other debris were present in the nest.

Males taken October 30 and June 13 and weighing 14.3 and 14.8 gms, respectively, were not fertile. A breeding male, weighing 19.4 gms, was trapped April 24. An adult 22.2 gm female obtained October 30 had enlarged teats but was not lactating. An apparently nulliparous female weighing 20.1 gms was collected June 13.

External measurements of four specimens were: total length, 164.8 mm (147 - 176); tail, 77.8 mm (70 - 84); hind foot, 17.8 mm (17 - 18). Skull measurements of two specimens were: occipitonasal length, 24.3, 25.3 mm; condylobasal length, 22.8, 24.2 mm; zygomatic breadth, 12.7, 14.1 mm; depth of brain case over basisphenoid, 8.2, 8.2 mm; interorbital constriction, 3.8, 4.2 mm; length of nasals, 8.7, 9.5 mm; length of incisive foramina, 4.6, 4.9 mm; length of palatine bridge, 3.8, 4.1 mm; length of maxillary tooth row, 3.9, 3.8 mm.

In depth of braincase and relative length of incisive foramina and palatine bridge, these southern Illinois specimens agree with *P. n. aureolus* rather than *P. n. flammeus* as described by Goldman (1941). They also appear not to differ significantly in coloration from a series of *aureolus* from Florida.

Specimens were taken at the following localities: Alexander Co.—½ mile

NNW of Olive Branch (1), 3 miles NNW of Olive Branch (1); Union Co. —1¾ miles E of Aldridge (2), 5½ miles NW of Cobden (1).

Neotoma floridana illinoensis A. H. Howell. Eastern woodrat. —Nineteen woodrats were trapped in Union County along the bluffs east and southeast of Aldridge and ½ mile east of the town of Wolf Lake. Signs of the species were noted at Chalk Bluff, 5¼ miles NW of Pomona in Jackson County, and evidence was obtained of the occurrence of *Neotoma* at two localities in the eastern part of the state where it has not heretofore been reported. Characteristic deposits of feces were found on ledges of the cliffs at Burden Falls, 1¾ miles NE of McCormick, Pope Co., and in a cave 2¼ miles N of Rosiclare in Hardin County. The cave was situated in rather flat terrain of second growth hardwoods and agricultural lands. Large accumulations of pellets were noted in two places deep within the cave. Nearby, a mass of typical woodrat trash consisting of sticks, nut hulls, dried leaves, and other debris was found spilling out of a crevice in the wall. Since no specimens were collected at either the Pope or Hardin county localities, the taxonomic status of the populations is questionable. The range of *Neotoma* in southern Illinois may be continuous across the lower end of the state by virtue of the Ozark Ridge, which extends from Jackson and Union counties on the west, to Pope and Hardin counties on the east. On a geographic basis, woodrats in southeastern Illinois might be expected to show intergradation between *N. f. illinoensis* and *N. f. magister*, which has been reported in southern Indiana (Kirkpatrick and Conaway, 1948) within 130 miles of the nearest Illinois locality.

In the areas where woodrats were trapped or their signs observed, population densities appeared highest in the Pine Hills region near Aldridge. Here 18 specimens were collected in 125 trap nights along a stretch of approximately four miles of limestone bluffs. The latter fronted on swampy bottomland forests or cultivated fields. The relatively steep slopes between the bare rock outcrops and at the base of the cliffs were forested chiefly with oaks, hickories, hackberry, elm, pawpaw, and sassafras. Sections of the bluffs that were rough and broken seemed to be preferred by the woodrats over those that were well weathered and smooth, probably because they provided more ledges for pathways and a greater number of suitable crevices for nest sites. It is doubtful if the woodrats foraged to any great distance from the shelter of the bluffs. None were taken in traps set more than 10 yards from the cliffs, although in one instance a farmer reported that woodrats occasionally visited a corn crib that was situated some 70 yards from a bluff inhabited by the animals. No indication of the presence of woodrats in the bottom woodlands adjacent to the bluffs was found. This agrees with the contention of Howell (1921) that *Neotoma floridana* prefers rocks to trees or logs for its habitations.

Of the 18 individuals caught in the Pine Hills, five were secured in traps set on the ground at the very base of the bluffs. The remainder were collected on the bluffs themselves at heights ranging

from 4 to 40 feet above the nearest ground. Most of these specimens were trapped on ledges that were overhung by the face of the cliff or in recesses in the rock, suggesting that the animals tend to take advantage of protective cover during the course of their nightly meanderings. Fecal depositories were most frequently observed in similar sites.

Many nests were apparently placed deep within narrow crevices in the cliffs. Although the actual nest structure was not visible in such cases, the floor of the passageway presumed to lead to the nest was usually covered with sticks, dirt, dried leaves, and other rubbish, which frequently spilled out onto the ledge on which the entrance opened. In one instance an opening apparently leading to a nest was completely lined with sticks and other debris so that its size was restricted to about that of a woodrat's body. Several large stick nests were discovered well within fissures in the bluffs.

Trapping records support the idea that fully-grown woodrats are essentially solitary. On one occasion two juveniles about 8 weeks of age were trapped within 4 feet of a nest crevice on the same night. Although several traps were ordinarily set at a given station, only single individuals were captured at all other times. In several cases, two animals were taken at the same site at intervals of a few months.

Evidence of the transportation of miscellaneous objects by the woodrats was observed. Once a few bits of broken glass and a smoothly worn stick were found on an accumulation of droppings on a ledge and had probably been brought there by a woodrat. On another occasion a small stone was found in a live trap with a specimen that had been captured. Since the stone was too large to pass through the wire mesh of the trap, it was assumed that the animal had carried it into the trap. In another case a used photographic flash bulb that had been discarded at the base of a bluff was later found on a ledge some 30 feet away, presumably transported there by a woodrat. An individual kept in captivity for a number of months habitually deposited short pieces of wood in its food dish, even though they were removed each time fresh food was given.

Thirteen stomachs from woodrats collected in June, July, and August contained the remains of fleshy fruits, leaves, herbaceous stems, seed pods, and other plant materials in addition to traces of insects and, in the case of two specimens, several small feathers. Two stomachs obtained in January were almost entirely filled with mast, although traces of green vegetation were also present. Gnawed remains of acorns, black walnuts, pods, and miscellaneous small seeds were frequently seen on ledges and in crevices frequented by woodrats. However, some of this feeding evidence may be attributable to white-footed mice, which were common associates of the woodrat.

The sexes of the 19 woodrats collected consisted of six males and 13 females. Two males collected in June and one in August were in full adult pelage and fertile. The three other males, taken in August, were subadult and contained no sperm in the cauda epididymis. The

weights of these specimens ranged from 150.0 to 202.9 gms. None of four postpartum females trapped in the months of June, July, and August were lactating. Placental scars in these individuals numbered 3, 4, 4, and 6. A gravid specimen obtained August 8 contained a single embryo measuring 13 mm in crown-rump length. Apparently this was the second pregnancy of the season for this individual, as old placental scars were visible in the uterine tubes and two sets of corpora lutea were evident in the ovaries. An adult female taken January 9 showed marked enlargement of the tubal genitalia, indicative of the onset of estrus. This single record suggests that the breeding season may commence in January. Six nonparous females taken in June, July, August, and January weighed from 108.9 to 179.9 gms.

The three adult males collected showed a brown stain on the hairs in the midventral line of the abdominal region due to the secretion of the sebaceous glands located in that area. The glandular field was particularly well marked in one individual by a sparsely haired patch about 55 mm long and 7 mm wide at its broadest part. Only a single female, trapped in January, exhibited even the faintest trace of such a stain. None of the subadults of either sex showed any discoloration of the hairs in the abdominal region.

Although no actual evidence of predation on woodrats was obtained, black snakes, *Elaphe obsoleta,* were encountered within crevices in bluffs where woodrats were common on two occasions. Rainey (1956) has mentioned the black snake as one of the important natural enemies of *Neotoma floridana* in Kansas.

A female woodrat live-trapped as an adult was kept in captivity from October until the following June. The woodrat proved to be of calm and gentle temperament, exhibiting little nervousness even while still in the trap. Within a few days following its capture, the animal would inquisitively approach to investigate a hand placed in the cage, and could be gently touched without becoming unduly alarmed or attempting to bite.

Mean and extreme measurements and weights of eight adults (2 males, 6 females) were: total length, 389.4 mm (366 - 406); tail, 184.5 mm (174 - 192); hind foot, 38.0 mm (36 - 40); ear from notch, 28.5 mm (26 - 31); weight, 231.0 gms (171.5 - 306.5).

Synaptomys cooperi gossii (Coues). Bog lemming.—Ten *Synaptomys* (6 males, 4 females) were collected in a total of 753 trap nights. Despite the relative infrequence with which these microtines were trapped, they are probably not uncommon in suitable habitats throughout southern Illinois. Two were taken at Tamms in Alexander County. One of these was trapped in a runway in a thick grassy plot within a weedy field containing numerous heaps of cut brush, patches of brome sedge, many small trees and shrubs, and tangles of brambles. *Microtus ochrogaster* was the most common small mammal at this station, and *Blarina, Peromyscus leucopus,* and *Mus* were also taken. The other specimen was collected in a bare, well-worn runway in a low, moist

section of a brome sedge field with scattered small shrubs. A single *Cryptotis* was also taken in a nearby trap. Another bog lemming was captured in a brome sedge field in Pope County, approximately ½ mile NE of McCormick. This field was dry and well drained and contained many small saplings and dense patches of brambles and greenbrier. *Blarina* and *Microtus* were also recorded at this site.

Seven *Synaptomys* were collected in Union County. One was obtained on June 13 about 2 miles NE of Aldridge in a runway in dense grass cover in a brushy zone between a mowed levee bank and swampy woodlands. The remaining specimens were trapped in a marsh about 1¾ miles E of Aldridge. On January 28 - 29, 200 traps at this locality produced a single individual. Five others were taken in 298 traps set the night of February 5 - 6. The marsh covered an area of about two acres in extent. It was surrounded by bottom woodlands except at one end, which was bordered by a dirt road that ran alongside the base of a limestone bluff. Cat-tails, rushes, and grasses constituted the principal herbaceous plants, while numerous small trees and bushes were dispersed throughout the marsh. The periphery of the marsh was fairly dry but water stood to a depth of several inches toward the center, although close-set grassy hummocks and old stumps and logs half concealed by dense vegetation formed abundant, comparatively dry islands. Signs of bog lemmings in the form of piles of cut stems and green fecal pellets were extremely abundant. Although such signs occurred in all parts of the marsh, their greatest abundance seemed to be in the drier areas in the marginal zone. The majority of feeding sites and fecal depositories were located in more or less concealed places, such as at the base of thick clumps of vegetation or in snug retreats beside or beneath rotting logs or stumps partially screened by matted vegetation. A few well-defined trails were noted along the periphery of the marsh, but none were evident in the wetter parts. The small mammal associates of *Synaptomys* in this habitat included *Peromyscus leucopus, Pitymys* (a single specimen taken in a dry site), and *Mus.*

A nest believed to be that of *Synaptomys* was found at the locality east of Aldridge. It was situated in a shallow depression in the ground amidst a clump of rushes (*Juncus*) surrounding the bases of two small trees growing at the edge of the marsh. It was roughly spherical and had an outside diameter of about 10 inches. It possessed a coarse outer layer of herbaceous stems and leaves that formed a thick platform upon which the nest rested and extended upwards to partially roof over an inner nest approximately 4 or 5 inches in diameter. The latter was composed of finely shredded dried plant materials. The nest chamber was dry and contained fleas, mites, small beetles, various insect larvae, a few green cuttings, and several characteristic *Synaptomys* droppings. A well-defined runway led to the nest.

The stomachs of all specimens examined contained only finely comminuted remains of unidentifiable green vegetation. Cuttings

observed during January and February in the drier areas of the marsh consisted almost entirely of the rush *Juncus effusus*. In many of the piles of cuttings closely examined it was found that the mice in their feeding had removed only the outer tissues and left fragile cylinders of pith. Grasses constituted most of the cuttings observed in the wetter areas of the marsh during the winter months. In June, fresh cuttings at this site consisted principally of the sedge *Carex lucida* and manna grass, *Glyceria striata*.

Five males collected in January, February, April, and June contained sperm in the cauda epididymis. The testes of these individuals averaged 5.8 × 4.0 mm in length and width, respectively, and their body weights varied from 25.0 to 36.7 gms, with a mean of 31.0. A juvenile male, weighing only 12 gms, was trapped on February 6. Three of the four females taken in February and April were nulliparous, although in adult pelage. Their weights ranged from 22.0 to 32.2 gms. A pregnant female obtained February 6 weighed 49.5 gms and contained three well-developed fetuses measuring 21 mm in crown-rump length.

Mean and extreme measurements of four adults were: total length, 127.0 mm (120 - 138); tail, 19.2 mm (18 - 20); hind foot, 19.5 mm (19 - 20).

Microtus ochrogaster ochrogaster (Wagner). Prairie vole.—These mice were most abundant in well-drained open lands and occurred in moist situations much less frequently. Two specimens were taken in a meadow of rank vegetation bordering a small stream and another in a narrow, wet, grassy strip between a road shoulder and flooded swamp. Fifteen individuals were trapped in a well-drained stand of purpletop, *Triodia*. The remainder of those collected were obtained in brome sedge or weedy fields with many scattered small trees and shrubs and clumps of trumpet creeper, brambles, or greenbrier in addition to thick patches of grass. Prairie voles were caught in traps set on bare earth in sparsely vegetated sites as well as in well-defined trails in areas of thick cover. They were often abundant in the vicinity of brush piles when these were present in the habitat.

Six of eight males taken in October were fertile, while two, weighing 11.0 and 24.4 gms, had not yet attained puberty. Fourteen males collected during April and May were all sexually active. Three adult and two nulliparous females were trapped in October. The latter weighed 23.0 and 24.2 gms. Eighteen adults and four subadults, ranging from 19.2 to 22.0 gms, were secured in April and May. Gravid individuals or specimens with prominent placental scars were obtained in each of the months in which this species was trapped. Placental scars in seven females varied from 3 to 7, with a mean of 4.7. Eleven females contained embryos or fetuses ranging from 2 to 5 in number and averaging 3.5.

Measurements of 15 adult males and 14 adult females were: total length, 146.5 mm (131 - 162); tail, 33.2 mm (28 - 37); hind foot,

18.9 mm (16 - 20). The weights of 29 adults (15 males, 14 non- or early pregnant females) averaged 37.7 gms (27.4 - 55.5).

Forty-nine specimens were taken at the following localities: Alexander Co. —Cache (10), ½ mile NW of Cache (1); 3¼ miles NNW of Olive Branch (12), Tamms (15); Jackson Co.—Carbondale (2); Massac Co.—Metropolis (5); Pope Co.—½ mile E of McCormick (2); Union Co.—4 miles NW of Cobden (2).

Pitymys pinetorum (Le Conte). Pine mouse. — Eight pine mice were collected at Carbondale and two in Union County approximately 1¾ miles E of Aldridge. Seven specimens were trapped in a grassy field with many bushes, patches, of brambles, and mats of honeysuckle. One individual was taken in the dense grass along a road shoulder in a predominantly forested area, while another was caught in the comparatively dry margin of a marsh situated in bottom woodlands. A single pine mouse was taken in a mole burrow in a fallow field; all others were trapped in well-defined surface trails.

Four adult males with sperm in the cauda epididymis were collected in August, January, February, and March. An immature male weighing 9.6 gms was taken in August. Three pregnant females trapped in August and October contained two embryos each. A third resorbing embryo was present in one of these. Two placental scars were visible in a female obtained August 12. Another trapped August 13 was fully grown but showed no sign of sexual activity.

Measurements of four adult males and five adult females were: total length, 121.0 mm (112 - 128); tail, 19.6 mm (18 - 21); hind foot, 17.0 mm (16 - 18). Weights of three adult males and one postpartum female averaged 25.8 gms (19.5 - 30.4).

Cory (1912) referred southern Illinois specimens of *Pitymys pinetorum* to the subspecies *scalopsoides*. Necker and Hatfield (1941) list both *scalopsoides* and *auricularis* from that part of the state, while Hamilton (1943) and Hoffmeister and Mohr (1957) indicate only the latter as occurring in southern Illinois. Although they may in actuality be intergrades, the specimens collected during this study appear to be closer to *auricularis* than *scalopsoides* on the basis of comparison with the original description of the former (Bailey, 1898) and with two New York and two New Jersey specimens of the latter.

Of five skulls from Jackson and Union counties the anterior margin of the interpterygoid fossa is definitely U-shaped in two, as is said to be characteristic of *auricularis*. In the other three the fossa is V-shaped and does not differ in outline from that in the skulls of *scalopsoides*. However, in all southern Illinois skulls the lateral pits of the palatines are distinctly shallower than in *scalopsoides*. The first pair of re-entrant angles of m_1 are noted by Bailey (1898) as meeting behind the anterior loop in *auricularis*. This condition exists in only one of the five southern Illinois skulls examined, although in the rest the angles more closely approximate each other than in any of the *scalopsoides* studied. Two adult skins from Jackson and Union counties also appear to approach *auricularis* in ear length and colora-

tion. The ear from notch (taken from the dried skin) measures 9.0 mm, as compared to 7.0, 7.5, and 7.5 mm in three adult *scalopsoides*. The southern Illinois specimens are darker than the *scalopsoides* available and also possess a buffy-brown wash over the entire venter, this coloration being either lacking or only slightly developed at mid-body in the latter.

Ondatra zibethicus zibethicus (Linnaeus). Muskrat.— One specimen was killed at a reservoir near Carbondale and another was drowned in a fish trap at Pyatt in Perry County. Muskrats were fairly common in ponds and lakes in the abandoned strip-mined lands at the second locality. Evidence of their feeding was frequently encountered in the stands of cattails occurring in many of the ponds and lakes of the area. Occasionally the animals dug pits in the soft bank at the water's edge to reach the underground portions of the plants.

Measurements and weights of the two specimens collected were: total length, 550, 667 mm; tail, 245, 270 mm; hind foot, 82, 83 mm; weight, 906, 975 gms.

Rattus norvegicus (Berkenhout). Norway rat.— No specimens were taken by trapping, and the only actual record obtained was of a road-killed specimen noted July 25 about 2 miles W of Murphysboro in Jackson County.

Mus musculus Linnaeus. House mouse. — Seventy-two specimens were collected. The major habitats in which house mice were trapped, together with the relative abundance of the species in each (in terms of the average number of trap nights necessary to capture one individual), are as follows: grassy or weedy fields with scattered brush — 24; roadside ditch bank and border of wet swale—2; edge between old fields and woodlands — 8; swampy woodlands — 208 (specimens taken only in an open, brushy site at edge of road shoulder); dense thickets of willow, mulberry, and sycamore draped with grape vines and bordered by a stand of giant ragweed — 52; and a marsh in low woodlands — 109 (mice trapped in both wet and dry situations).

A total of 45 males and 29 females was trapped from July through the following May. Breeding males were obtained in August, December, January, April, and May. Of those individuals that could be classified as being definitely fertile or non-fertile on the basis of the degree of enlargement of the cauda epididymal tubules or the presence or absence of sperm in a smear of the epididymis, the number of breeding to non-breeding males was approximately equal in April and May (5 and 4 animals, respectively), whereas in the interval from July to January only seven breeding to 22 non-breeding specimens were obtained. Eight out of nine fertile males examined from April through October exceeded 14 gms in weight. During the same period, 16 of the 20 non-breeding animals examined weighed less than 14 gms. This figure may therefore be assumed to be the approximate weight at which feral house mice in southern Illinois attain puberty, at least during the warmer months of the year. In December and

January only three males were classed as being fertile, although eight of the 11 specimens collected weighed more than 14 gms. This relatively high proportion of heavy, non-breeding mice is suggestive of a lull in male reproductive activity in the colder months. This partial cessation of reproductive activity may result from the passage of some adults into a sexually quiescent condition, the postponement of puberty in individuals born late in the season, or a combination of both factors.

Ten of 18 females taken in October and December and two of three individuals collected in April were nonparous. Females appeared to reach puberty at about the same body weight as males, the best dividing line between adult and non-bred animals with respect to body weight also being 14 gms. The sole instance of overlap in the females was a 12.4 gm pregnant specimen obtained in May. This single record suggests the possibility that breeding may commence at an earlier age in spring than later in the season. Two gravid females, containing five and seven embryos, were collected in August and May. Single lactating specimens were also taken in each of these months. Placental scars in six females ranged from 5 to 8, with an average of 6.3.

Means and observed ranges in measurements and weights of 15 adults (8 males, 7 females) were: total length, 168.7 mm (154 - 182); tail, 80.8 mm (74 - 90); hind foot, 17.7 mm (16 - 19); weight, 18.4 gms (14.5 - 25.0).

Specimens were collected at the following localities: Alexander Co.—Cache (3), 1½ miles NW of Cache (2), 2½ miles SE of Cairo (8), ½ mile NNW of Olive Branch (8), 3 miles NNW of Olive Branch (2), Tamms (4); Jackson Co.—Carbondale (19), 3 miles N of Pomona (13); Union Co. —1¾ miles E of Aldridge (3), 3 miles N of Cobden (5), 4 miles N of Cobden (5).

Zapus hudsonius (Zimmermann). Meadow jumping mouse. —Two specimens were collected in Union County. One, a subadult male, was found on October 8 swimming weakly within a sunken tile in a spring approximately 1½ miles SE of Aldridge. The spring was located at the foot of a limestone bluff. Except for a small, open, grassy plot between the spring and a road, the area was generally wooded. The second specimen was trapped in a brushy field near a stream by Earl Stadelbacher on April 24 approximately 5½ miles NW of Cobden.

The subadult had testes measuring 4 × 3 mm and contained no sperm in the cauda epididymis. The adult was fertile, with testes measuring 10 × 6 mm.

Krutzsch (1954), although noting that specimens of *Zapus hudsonius* from eastern and southern Illinois show evidence of intergradation with contiguous subspecies, refers all material from the state to the subspecies *intermedius*.

Measurements and weights of the subadult and adult specimens, respectively, are as follows: total length, 192, 210 mm; tail, 117, 126

mm; hind foot, 29, 30 mm; ear from notch, 13, 16 mm; weight, 15.0, 17.3 gms.

Canis latrans Say. Coyote.— An adult female was trapped by B. J. Verts in an abandoned strip-mined area at Pyatt in Perry County on December 4. Faint placental scars were visible in the uterine horns and regressed corpora lutea of the previous breeding season were still present in the ovaries. The specimen weighed 23 lbs. and had the following measurements: total length, 1218 mm; tail, 353 mm; hind foot, 191 mm.

Vulpes fulva (Desmarest). Red fox. — The red fox appears to be less common in southern Illinois than the gray fox; some experienced hunters rate the latter as at least twice as abundant as the former. Local persons familiar with the habits of the two species claim that the gray species prefers the hilly uplands, while *Vulpes* is a more typical inhabitant of the bottomlands.

The single specimen examined was an adult male killed April 15 in Union County near Alto Pass. It had already passed out of breeding condition, as evidenced by the lack of sperm in a smear of the cauda epididymis and the darkened, regressed condition of the prostate gland. Its measurements and weight were: total length, 1031 mm; tail, 365 mm; hind foot, 165 mm; weight, 10 lbs. 11 oz.

Additional records include a road-killed specimen noted in Jackson County approximately 2 miles NE of Gorham and a pup about 12 to 14 weeks of age observed at night near Cobden, Union County, on April 1.

Urocyon cinereoargenteus cinereoargenteus (Schreber). Gray fox. — This species is abundant in southern Illinois, occurring in both bottomland and hilly upland habitats. Except for two specimens found dead on highways and one killed during a rabbit hunt, all individuals examined were taken by means of a hunting method that attained great popularity among southern Illinois hunters in the winter of 1954 - 55.

The method consisted of decoying foxes within shotgun range by means of special call producing a sound akin to the cry of a wounded rabbit. A few animals were killed during the day from concealment, but the vast majority were shot at night. A stand would be taken in an open spot affording a clear view for a hundred or so yards around the hunter but located in proximity to suitable cover. The hunters usually worked in pairs or groups of three or four, the individuals standing closely back to back and each covering a given sector. Head lamps were used and these were kept on with the beam directed upwards at about a 45° angle. All parts of the gun and body were kept behind the beam. Moonless nights were considered most favorable for this activity, since on bright nights it was claimed that an approaching fox could perceive the hunters behind the lights. The most satisfactory method of calling appeared to be a sequence of several calls given in rapid succession alternating with a short pause. Foxes responding at a given stand would usually appear within five

or ten minutes and often much sooner. The shine of the eyes in the side beams of the head lamps was usually visible while the animal was still at a considerable distance. When the fox had been lured within shot-gun range, the light was directed full upon it. Usually the animal remained motionless for a few moments, thus offering a comparatively easy target. Gray foxes were easily attracted to within 25 or 30 yards and not infrequently came much closer. Occasionally an individual would bark or growl as it approached the sound, and often two or more animals would appear simultaneously.

Red foxes, although also attracted to the call, appeared much more cautious than the gray fox. They usually remained well out of gun range while investigating the situation and then quietly disappeared. An indication of the difference in response of the two species to this kind of hunting is obvious from the fact that in a sample 216 foxes taken by this method only one was a red fox. The effectiveness of the technique in hunting gray foxes is well illustrated by the fact that one group of hunters, concentrating their activities within a radius of a few miles of one town, was known to have killed 187 foxes in the interval from late December through June.

Reproductive data obtained from 218 specimens have been presented elsewhere (Layne, 1958). Only a few miscellaneous observations will be noted here. The stomach of a specimen killed in March contained a large amount of corn and two *Peromyscus leucopus*. The stomach of a fox shot in December contained principally cottontail remains, in addition to part of a white-footed mouse, some small bird feathers, fragments of corn, and a persimmon seed. Another late December stomach contained the remains of a rabbit, believed to be *S. aquaticus*, a *Microtus*, and a small bird. An albino gray fox was killed by George Irwin near Cutler, Perry County, on March 11.

Mean measurements of 25 adult males and 25 adult non- or early pregnant females, respectively, and the observed ranges for the entire series were: total length, 936.8, 927.3 mm (860 - 1005); tail, 310.1, 313.5 mm (218 - 344); hind foot, 137.2, 130.0 mm (114 - 148). The weights of these individuals varied from 7 lbs. 3 oz. to 11 lbs. 4 oz., the males averaging 9 lbs. 8 oz., and the females, 8 lbs. 13 oz.

Specimens were obtained from the following localities: Alexander Co.—½ mile NW of Cache (1); Jackson Co.—Boskydell (2), Carbondale (2), Vergennes (4); Johnson Co.—Grantsburg (1); Perry Co.—Cutler (1); Union Co.—Aldridge (Pine Hills Area) (2), vicinity of Alto Pass (187), Anna (2), vicinity of Cobden (16). An individual was seen crossing a road at night near McCormick, Pope County.

Procyon lotor lotor (Linnaeus.) Raccoon.—The raccoon is abundant in southern Illinois and generally distributed in a variety of habitats ranging from abandoned strip-mined lands to bottomland forests. It is in the latter habitat that the species perhaps reaches its greatest numbers in this region. Raccoon tracks were also commonly encountered deep within caves visited in Union and Hardin counties during the winter months in search of bats.

A male taken November 19 was in full breeding condition. Two females collected March 30 and 31 were in advanced pregnancy. One individual contained two nearly full-term fetuses. The second had a single normal fetus in one uterine horn and a resorbing embryo in the other. Two lactating females were obtained April 30 and May 1. Placental scars distinguishable in the uterine horns of these specimens numbered three and five.

Three of four stomachs examined contained corn in considerable quantity. One had a few persimmon remains and another fragments of unidentifiable vegetation. Crayfish remains were present in three of the stomachs, earthworms in two, and beetles in one.

External measurements and weights of an adult male and four females were: total length, 775.2 mm (723 - 821); tail, 271.8 mm (243 - 300); hind foot, 106.2 mm (102 - 113); weight, 11 lbs. (9 lbs. 4 oz. — 14 lbs. 10 oz.). Means and ranges of measurements of four skulls from Union County and one from Perry County were: greatest length, 110.5 mm (107.4 - 113.8); condylobasal length, 105.4 mm (103.6 - 107.4); zygomatic breadth, 69.4 mm (60.9 - 76.3); least width of palatal shelf, 15.8 mm (15.2 - 17.1); maxillary tooth row, 40.4 mm (39.2 - 41.1); interorbital breadth, 23.2 mm (21.3 - 26.2).

Goldman (1950) referred five specimens from southern Illinois (Belleville, Olive Branch, and Rosiclare) to *P. l. lotor*. With the sole exception of tail length, the present specimens average smaller in all external and skull dimensions than the six *lotor* from Nova Scotia, Connecticut, New York, and Virginia noted by Goldman. It appears, therefore, that southern Illinois raccoons evidence in their smaller size an approach to *P. l. varius*.

Localities at which raccoons were collected are as follows: Jackson Co.—4 miles N of Vergennes (1); Union Co.—3 miles N of Cobden (2), 4 miles NW of Cobden (1), 4 miles S of Jonesboro (1); Williamson Co.—Cambria (1). An additional skull examined was one collected by B. J. Verts at Pyatt, Perry Co.

Mustela vison Schreber. Mink. — Although no specimens were collected, tracks of this species were noted along the margin of a large pond in the abandoned strip-mined lands at Pyatt, Perry County, on July 13.

Mephitis mephitis (Schreber). Striped skunk. — Road-killed specimens were collected at Alto Pass (1) and 1½ miles N of Cobden (1) in Union County and 5 miles E of Carbondale in Williamson County (1). Two females were obtained in September and February. A male obtained in January weighed 5 lbs. 13 oz. and contained sperm in the cauda epididymis.

Measurements of an adult male and female, respectively, were: total length, 630, 716 mm; tail, 210, 254 mm; hind foot 68, 63 mm; ear from notch, 25, 22 mm.

Necker and Hatfield (1941) lumped all records of the striped skunk in Illinois under *M. m. avia*, while Hamilton (1943) and Hoffmeister and Mohr (1957) indicate that *M. m. nigra* is the subspecies

present in the southern part of the state. In tail length, the present specimens agree more closely with *nigra* than *avia*.

Lynx rufus (Schreber). Bobcat. — The bobcat is apparently not uncommon in certain areas of southern Illinois, particularly the bottoms of the Ohio and Mississippi rivers in the extreme tip of the state. While no specimens were actually collected, several records were obtained from persons considered to be reliable observers. John Heaman of Cairo informed me that bobcats were fairly common in the vicinity of Dog Tooth Bend, a narrow tongue of land bounded by a sharp bend of the Mississippi near Cairo. On or about December 18 he saw a bobcat at close range on a road traversing this area. Ronald Yates of Metropolis recalled that a "37-pound" bobcat had been taken in the Mermet Bottoms about 10 miles N of Metropolis, Massac County, about 1950. The animal was treed by hounds after a 4-hour chase and was killed. The skin was reportedly saved. Leland McDonald of Pinkneyville reported seeing a bobcat crossing a road late at night in a strip-mined area between Pinkneyville and DuQuoin in Perry County about 1952. A further record is provided by a photograph, published in the *Cairo Evening Citizen* on February 25, 1955, of a bobcat killed by a train approximately 10 miles N of Cairo. The cat was stated to have weighed 21 lbs.

Odocoileus virginianus (Zimmermann). White-tailed deer. — Remnants of the original Illinois deer population are believed to have persisted in the southern part of the state until shortly after 1910 (Pietsch, 1954). According to the same author, the re-establishment of the white-tail in southern Illinois was initiated through introductions in Alexander, Pope, and Union counties during the 1930's together with some possible ingress of animals from Missouri. Today, the 11 southernmost counties in the state comprise one of the two principal deer ranges in Illinois.

During the course of the present field work deer tracks were noted 2 miles NW of Cache in Alexander County and at the following localities in Union County; Aldridge (Pine Hills), Union County Refuge near Ware, and 2½ miles SW of Ware. Signs were observed most frequently in bottomland tracts. Leland McDonald of Pinkneyville reported that a herd of about 40 deer was believed to reside in Perry County and that two individuals had been seen within the town of Pinkneyville during December, 1954. A sizeable herd also inhabits the Crab Orchard Wildlife Refuge in Williamson County.

REFERENCES

BAILEY, V. 1898—Descriptions of eleven new species and subspecies of voles. Proc. Biol. Soc. Wash. 12:85-90.

BAUMGARTNER, L. L. 1943—Pelage studies of fox squirrels (*Sciurus niger rufiventer*). Amer. Midl. Nat. 29:588-590.

BOLE, B. P., JR. AND P. N. MOULTHROP 1942—The Ohio Recent mammal collection in the Cleveland Museum of Natural History. Sci. Publ. Cleveland Mus. Nat. Hist. 5:83-181.

CAGLE, F. R. AND L. COCKRUM 1943—Notes on a summer colony of *Myotis lucifugus lucifugus*. J. Mamm. 24:474-492.

CHRISTIAN, J. J. 1953—The natural history of a summer aggregation of *Eptesicus fuscus fuscus*. Naval Med. Res. Inst. Memorandum Rept. 53-16:161-193.

CORY, C. B. 1912—The mammals of Illinois and Wisconsin. Field Mus. Nat. Hist. Publ. 153.

GEIS, A. D. 1957—Coprophagy in the cottontail rabbit. J. Mamm. 38:136.

GOLDMAN, E. A. 1941—A new western subspecies of golden mouse. Proc. Biol. Soc. Wash. 54:189-192.

———1950—Raccoons of North and Middle America. N. Amer. Fauna No. 60.

GOODPASTER, W. W. AND D. F. HOFFMEISTER 1952—Notes on the mammals of western Tennessee. J. Mamm. 33:362-371.

HALL, E. R. 1951—A synopsis of the North American Lagomorpha. Univ. Kans. Publ. Mus. Nat. Hist. 5:119-202.

HAMILTON, W. J., JR. 1943—The mammals of Eastern United States. Comstock Publ. Co., Ithaca, New York.

———1955—Coprophagy in the swamp rabbit. J. Mamm. 36:303-304.

HANDLEY, C. O., JR. 1955—New bats of the genus *Corynorhinus*. J. Wash. Acad. Sci. 45:147-149.

HOFFMEISTER, D. F. AND C. O. MOHR. 1957—Fieldbook of Illinois mammals. Ill. Nat. Hist. Survey Div. Manual 4.

HOWELL, A. H. 1921—A biological survey of Alabama. N. Amer. Fauna No. 45.

JONES, G. N. 1950—Flora of Illinois. Amer. Midl. Nat. Monogr. No. 5.

KING, D. B. AND R. K. WINTERS 1952—Forest resources and industries of Illinois. Univ. of Ill. Agr. Exp. Sta. Bull. No. 562.

KIRKPATRICK, C. M. 1956—Coprophagy in the cottontail. J. Mamm. 37:300.

———AND C. H. CONAWAY 1948—Some notes on Indiana mammals. Amer. Midl. Nat. 39:128-136.

KRUTZSCH, P. H. 1954—North American jumping mice (Genus *Zapus*). Univ. Kans. Publ. Mus. Nat. Hist. 7:349-472.

LAYNE, J. N. 1958—Reproductive characteristics of the gray fox in southern Illinois. J. Wildlife Mgt. 22:157-163.

LEICHLEITNER, R. R. 1957—Reingestion in the black-tailed jack rabbit. J. Mamm. 38:481-485.

LEIGHTON, M. M., G. E. EKBLAW AND L. HORBERG 1948—Physiographic divisions of Illinois. J. Geol. 56:16-33.

NECKER, W. L. AND D. M. HATFIELD 1941—Mammals of Illinois. Bull. Chi. Acad. Sci. 6:17-60.

NELSON, E. W. 1909—The rabbits of North America. N. Amer. Fauna No. 29.

PAGE, J. L. 1949—Climate of Illinois. Univ. of Ill. Agr. Exp. Sta. Bull. No. 532.

PIETSCH, L. R. 1954—White-tailed deer populations in Illinois. Ill. Nat. Hist. Surv. Biol. Notes No. 34.

RAINEY, D. G. 1956—Eastern woodrat, *Neotoma floridana*: life history and ecology. Univ. Kans. Publ. Mus. Nat. Hist. 8:535-646.

SMITH, P. W. AND P. W. PARMALEE 1954—Notes on distribution and habits of some bats from Illinois. Trans. Kans. Acad. Sci. 57:200-205.

WETZEL, R. M. 1947—Additional records of Illinois mammals. Ill. Acad. Sci. Trans. 40:228-233.

Notes and Discussion

Change of Type Depository

Reference is made to *The American Midland Naturalist*, Vol. 57, No. 2, pp. 453 and 454. The holotype and allotype of *Dermanyssus becki* Allred and the holotype of *Hirstionyssus femuralis* Allred are in the collection of the author.—Dorald M. Allred, Department of Zoology and Entomology, Brigham Young University, Provo, Utah, U. S. A.

A New Variety of Thalictrum Revolutum DC.[1]

Thalictrum revolutum DC. var. **glandulosior** var. n. Ramis petioli glandulosis. Caulis nonnunquam atque stipulae inferne etiam glandulosi. Antherae minores, 1.2-2.0 mm.

Wisconsin, kenosha: *J. J. Davis*, Somers, July 8, 1909 (DAO); id, June 13, 1933 (DAO); id, June 14, 1933 (WIS); milwaukee: *I. D. Lapham*, Milwaukee (WIS); *C. Goesse*, Milwaukee, Menomenee R., Aug. 8, 1933 (WIS); racine: *J. J. Davis*, Racine (WIS); *J. R. Heddle 243*, Racine, bank of Root River at Cedar Bend, July 7, 1906 (WIS); walworth: Williams Bay, marsh, September 2, 1909 (WIS); *J. W. Thomson*, Williams Bay, 1 mile E., Crane Farms, low prairie, July 8, 1941 (WIS type, DAO fragment); *S. C. Wadmond*, Williams Bay, low mucky prairie just north of C & NWRR station, August 6, 1933 (WIS); waukesha: *L. H. Shinners 2070*, New Berlin, C & NW west of Sunny Slope Road, June 30, 1940 (WIS).

Typical *T. revolutum* is glandular pubescent on the underside of the leaflets, the peduncles and the ovaries, but the Wisconsin specimens are also glandular on the ramifications of the petiole and also, usually, on the back of the stipular bases and on the stem.—B. Boivin, Science Service Building, Ottawa, Ontario.

---

[1] Contribution No. 1618 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

Book Review

THE MUSHROOM HUNTER'S FIELD GUIDE. By Alexander H. Smith. University of Michigan Press, Ann Arbor. 1958. 197 pp., 155 figs. $4.95.

The humanitarian desire to prevent mushroom hunters from incurring needless medical and mortuary expenses appears to have been the chief motivation for this excellent guide. It is evident from his introductory remarks that Dr. Smith is reluctant to write a "popular" treatise which cannot, by the very nature of his subjects, be completely reliable scientifically. Both in the introduction and in the text, reference is made to the great variability between individual specimens of the same species and to the necessity for the use of microscopic characteristics for scientifically accurate determinations of certain species.

The 124 species which are described are illustrated by photographs that are, in most instances, outstanding in their excellence. The text accompanying each photograph notes the season and habitat of the species, the important field characteristics, and the edible or poisonous features of the mushroom. Simple keys provide a guide to the principal groups of mushrooms and to the species within these groups. Characteristics such as the spore print which are not of service in the field have been omitted.

If asked to select the 124 most significant mushrooms of the northern United States, no two mycologists would be likely to choose the same species. Thus there is little point in commenting upon Dr. Smith's choice of species. Since the book is written for those who wish primarily to collect edible species and avoid poisonous ones, the omission of numerous common species of quite small size and of the common polypores of woody consistency is understandable.

Liberal use of scientific terms is made in the descriptions of field characteristics, but these are defined clearly in the glossary. There is also a general avoidance of all but the most widely known common names, an omission which is no loss. Several lists of mushrooms grouped according to season and habitat are included in the introduction. However the book lacks an alphabetical list of the species treated which might have profitably replaced the non-alphabetized list which follows the table of contents.

The size of the book — roughly 5 by 11 inches — is unusual but highly practicable, as it will slip conveniently into the pocket of a field jacket or rucksack. (This shape unfortunately has resulted in the undesirable cropping of some photographs.) A further utilitarian feature is the striking black and white cover with a vermillion band across the top which should facilitate its recovery if the book were carelessly left at the last collecting spot.

Occasional comments are made concerning the length of time and the preferred method of cooking particular species, but no specific recipes are given.

It is a book written by a scientist and a craftsman for lay readers, but will undoubtedly find a place on the shelves of many professional mycologists.— JOHN A. JUMP, Elmhurst College, Elmhurst, Illinois.

INSTRUCTIONS FOR AUTHORS

Manuscripts should be typewritten, double-spaced, with ample margins, on one side of 8½ x 11 inch paper. Tables and figures should be placed at the end of the manuscript. Each sheet should be numbered consecutively. The title and author's name along with the full mailing address of the author should be placed on the first page.

Style, arrangement, spelling, and abbreviations should conform to the usage of recent numbers of this journal. Do not underline any words except scientific names. Acknowledgements can be included in the Introduction, or may be offered as a footnote attached to the title of the article.

Papers should be concisely written. A subsidy will be required for papers which exceed twenty journal pages in length.

References should be listed alphabetically by authors' names. In the text they should be cited by author and date, e.g., Smith (1958). The form of the citations should be that used in this journal; in references to papers in periodicals, titles should be given and inclusive page numbers are required. All citations should be checked with the original articles. Abbreviations of the names of periodicals should conform with the listings in BIOLOGICAL ABSTRACTS 29(5):v-xxxv (May, 1955), or 30(5):xi-xxxii (May, 1956). Book citations should include author's name, complete title, edition, name and location of publisher, and total number of pages.

A condensed title for running page headlines, not to exceed forty letters and spaces, should be submitted on a separate page.

Authors should indicate on the manuscript the approximate position of text figures and tables. Tables should be numbered consecutively using roman numerals; use arabic numbers for figures. Titles for tables and figure legends should be brief. Photographic copies of black and white figures should also be submitted if the originals are larger than 8½ x 11 inches. Authors will be requested to pay for tabular material of more than two pages and for engraving costs above $10.00.

The editors reserve the privilege of returning to the author for revision approved manuscript and illustrations which are not in proper finished form for the printer.